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Heating • Piping and Air Conditioning

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JANUARY
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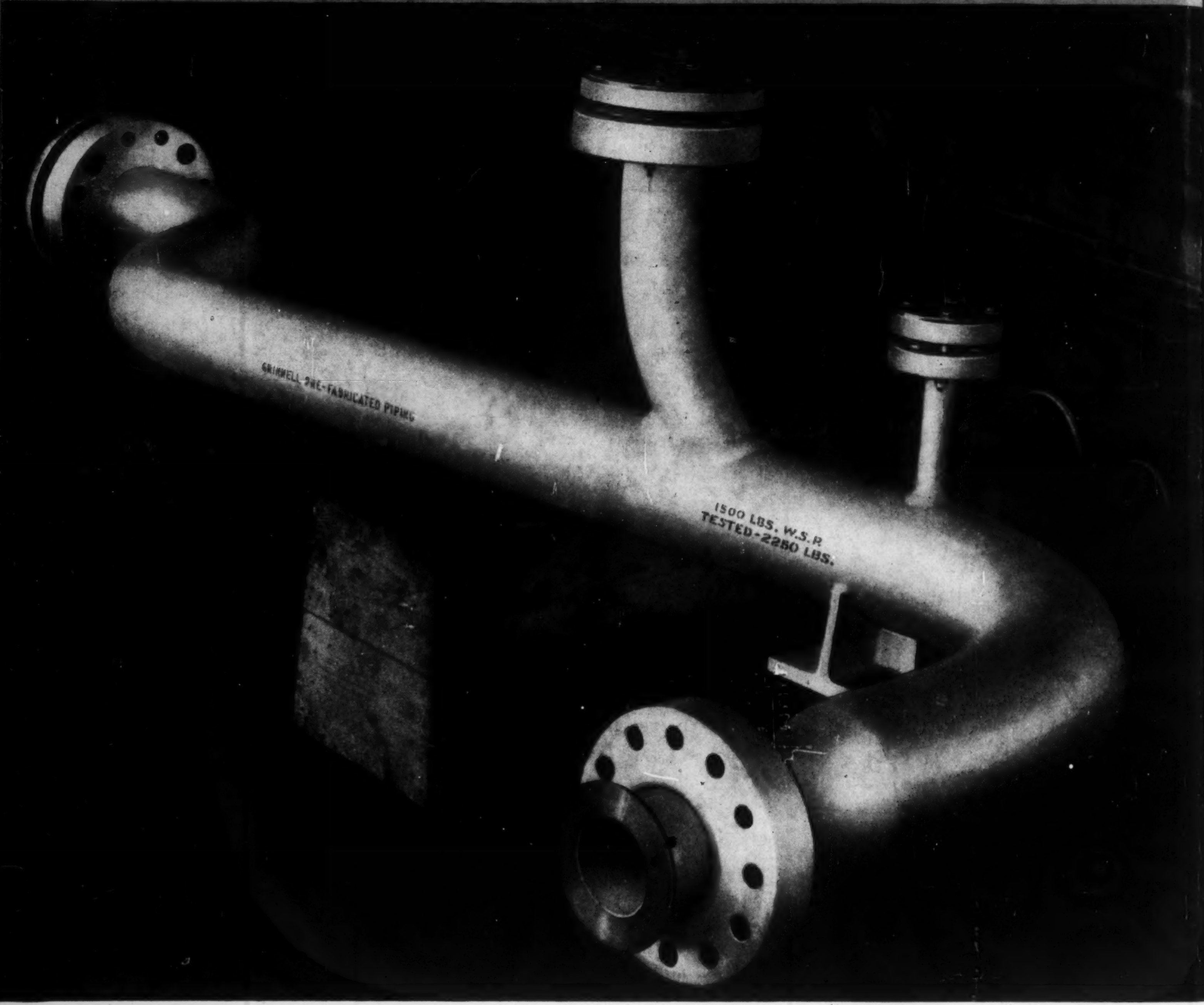
HOW TO *Sub-Contract* YOUR PIPING PROBLEMS!



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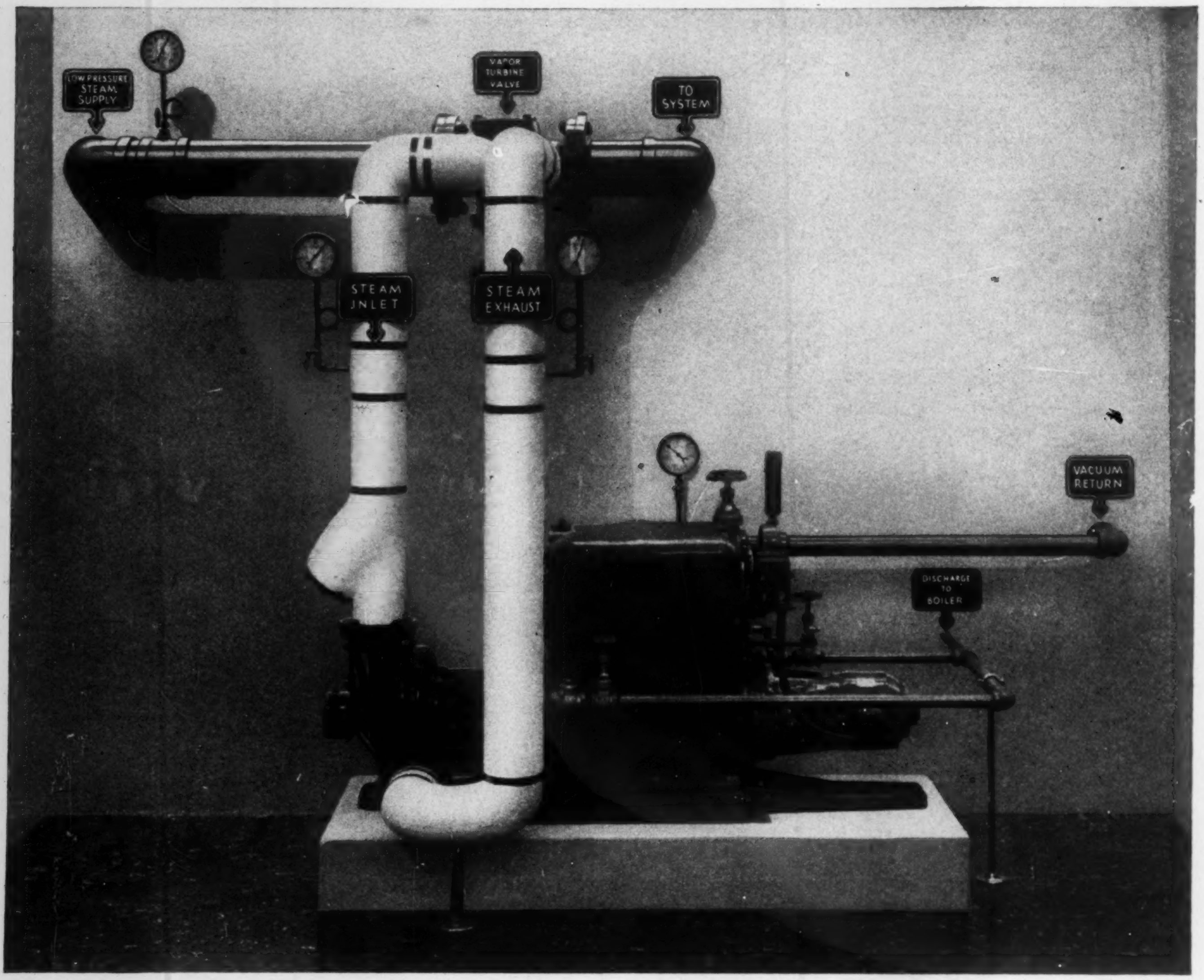
Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

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CODE FOR PRESSURE PIPING

Many Advances in Piping Incorporated in ASA Code, Which Has Been Revised and Will Be Reissued As a Full American Standard . . . . By Sabin Crocker

MANY advances in piping practice have come about since the ASA code for pressure piping (B31) was issued first as a tentative American standard in 1935.* Among the principal developments pointed out in the introduction to the revised code, which is about ready to come out as a full American standard after six years seasoning, are the following:

Welded joints have assumed increasing importance; standard dimensions have been prescribed for factory made, butt welding and socket welding fittings and their use has become common practice; welding end valves with welded bonnets have been developed and adopted; rules for reinforcing welded branch connections and for designing welded or cast specials have been added; rules have been added for combining expansion stresses with those due to internal pressure; new rules have been formulated for the qualification tests of welding processes and welding operators; pressures and temperatures have been advanced to new high points; new material specifications and dimensional standards have been formulated; and a section on refrigeration piping has been added in keeping with the growing importance of this industry in air conditioning as well as in older lines. All these are among the changes which ASA sectional committee B31 has considered and incorporated in the requirements of the new draft of the piping code in order to keep it abreast of the times.

Purpose of Code

This code is one of a series of safety codes on various subjects which have been, or are being, formulated under the general auspices of the American Standards Association. While the code is used extensively in construction contracts as a reference base for minimum safety requirements, its principal purpose is to serve as a guide for state and municipal authorities in case they should decide to adopt such regulations. In such cases, however, the code provides that it shall *not* be made retroactive or construed as applying to piping systems erected before, or under erection at the time of, its approval by the ASA. The code also will serve as a standard of reference for minimum safety requirements by equipment manufacturers, architects, engineers, erectors and others concerned with pressure piping.

PIPING CODE—Since the ASA code for pressure piping was first issued as a tentative standard six years ago, there have been many developments and advances in piping practices. Welded joints have assumed increasing importance, standard dimensions for various types of fittings have been established and come into common use, new rules and qualification tests have been formulated, and refrigeration piping has developed because of the growth of air conditioning and the older refrigeration applications. These and other factors have been among the changes which ASA sectional committee B31 has considered and incorporated in the new draft of the code for pressure piping in order to keep it abreast of the times. . . . In an extensive group of articles—of which this is the first—the new code, which soon will be a full American standard, will be described and discussed in detail. . . . Mr. Crocker—no stranger to HPAC's readers—is chairman of ASA sectional committee B31's subcommittee on plan, scope and editing; a member of HPAC's board of consulting and contributing editors; and senior engineer, engineering div. of The Detroit Edison Co.

In each field of piping covered, the code provides a standard of minimum safety requirements for: (1) The selection of suitable materials and reference to standard specifications by which they may be secured; (2) the designation of proper dimensional standards for the elements comprising piping systems; (3) the design of the component parts as well as the assembled unit, including necessary supports; (4) the erection of these systems; and (5) the test of the elements before erection and of the completed systems after erection. It is intended to set minimum safety requirements expressed in language which is intelligible to all who design, manufacture and erect piping systems, but not necessarily to cover the best practice known to the art. While in most cases the requirements are mandatory, design recommendations have been included where they will be of assistance in securing safe piping systems.

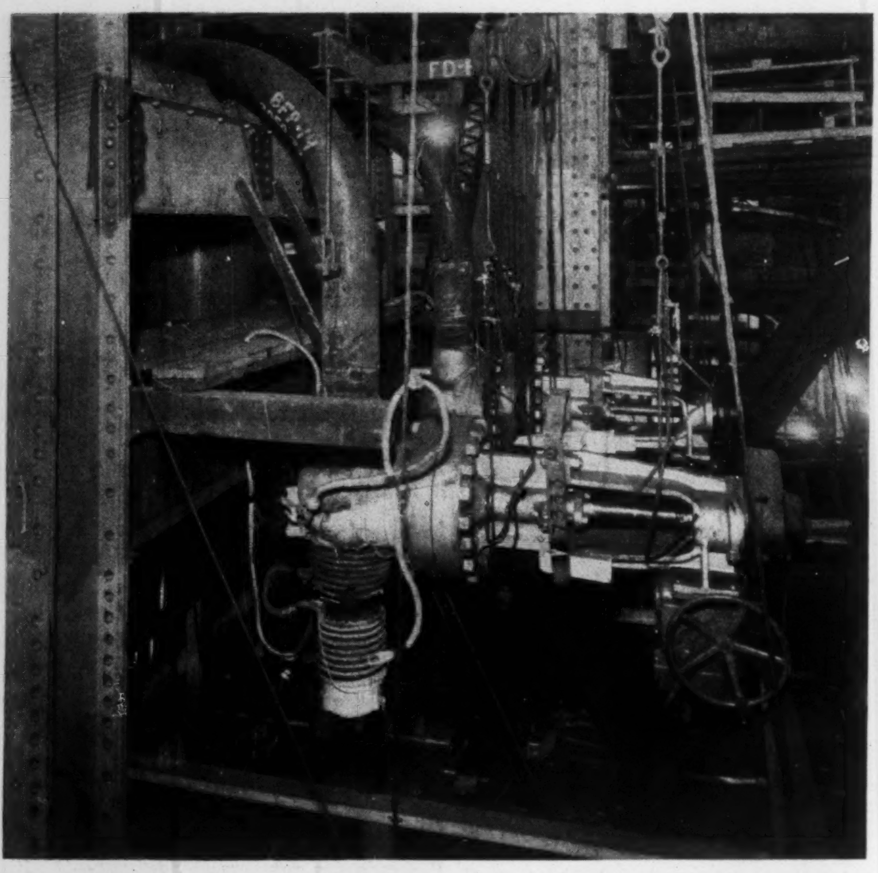
The sections which have been prepared and included in this second edition of the code are:

Section 1—Power Piping Systems.
Section 2—Gas and Air Piping Systems.
Section 3—Oil Piping Systems.
Section 4—District Heating Piping Systems.
Section 5—Refrigeration Piping Systems.
Section 6—Fabrication Details.
  Chapter 1—Pipe Hangers, Supports, Anchors, Sway Bracings and Vibration Dampeners.
  Chapter 2—Pipe Joints Other Than Welded.
  Chapter 3—Expansion and Flexibility.
  Chapter 4—Welding of Pipe Joints.
  Chapter 5—Welded Branch Connections and Fabricated or Cast Specials.
Section 7—Materials — Their Specifications and Indentification.

All sections have been extensively revised and enlarged to suit present-day practice, through embracing the advances mentioned at the beginning of this article. Owing to the introduction of a new section on refrigeration piping systems as No. 5, the old section on fabrication details and the section on materials have been advanced one place each in the numbering system. The section on hydraulic piping originally contemplated as coming within the scope of the code has not yet materialized because of lack of interest by this branch of industry.

---

*Those who are interested in the history of the piping code project and the reasons for its development can refer to a series of articles by Mr. Crocker published in HPAC, January through August, 1934, in which the code was "previewed" just before its original appearance in book form.



Gate valves in high pressure boilerfeed piping between pumps and heaters, Waterside No. 2 Station, Consolidated Edison Co. of New York. These valves conform to the 1500 lb series of American standard B16e-1939. Note the electric induction heaters in place which were used in preheating and stress relieving the welds. Such installations come under section 1 of the code for pressure piping

Detailed explanation of outstanding new features of the code will be furnished in future installments of this series which will take up the changes section by section. The balance of the present installment is devoted to an account of those changes which are common to several sections of the code without appearing in either of generalized sections Nos. *6* or *7*.

Pipe Wall Thickness

The principal pipe wall thickness formula, which appears in the several code sections for the various types of piping covered, constitutes one of the fundamentals of the code. The basic formula is:

$$t_m = \frac{PD}{2S} + C$$

where t_m = minimum pipe wall thickness in inches;

P = maximum internal service pressure in pounds per square inch gage (plus water hammer allowance in case of cast iron pipe conveying liquids);

D = outside diameter of pipe, in inches;

S = allowable stress in material due to internal pressure, at the operating temperature, in pounds per square inch, and;

C = allowance for threading, mechanical strength, and/or corrosion, in inches.

This is the well-known Barlow formula modified by the addition of a constant C which provides an allowance for threading, mechanical strength and/or corrosion. This formula, by reason of its simplicity in application, and its proved good accuracy in predicting the bursting strength of full length specimens of pipe subjected to hydrostatic bursting strength tests, was selected by the committee and reaffirmed for this edition of the code in preference to other formulas, which theoretically may be more correct.

Prior to its September 30, 1941, revision, the ASME boiler construction code differed from the power section of the code for pressure piping in that it had two bursting strength formulas, applicable to different size ranges, one of which differed significantly from the Barlow formula used in the piping code. In 1941, the ASME boiler code committee revised their paragraphs dealing with computation of pipe wall thickness to agree substantially with the requirements of the piping code. This is an important step toward harmonizing the requirements of the two codes, parts of which cover piping in the same general classification.

A major innovation in this new edition of the piping code, also recognized now in the boiler construction code, involves introduction of the Lamé formula as an alternate method for computing pipe wall thickness, particularly where the heavier walls are involved. The new formula has been added only to the power, oil and district heating sections since the pressures involved in piping for the gas and air and refrigeration sections were not considered sufficiently high, in general, to warrant use of the more complicated formula. The following version of the Lamé formula is taken from paragraph 122(b) of the power section:

> If the nominal pipe size is 4 in. or greater, and the minimum thickness of the pipe is equal to or greater than 10 per cent of the inside diameter, the minimum thickness may be determined from the following formula:
>
> $$t_m = \frac{D}{2}\left[1 - \sqrt{\left(\frac{S-P}{S+P}\right)}\right] + C$$
>
> where the symbols have the same definition as given above.

For higher pressures, the Barlow formula is overly conservative in that heavier wall thicknesses are provided than experience has shown to be necessary. The oil industry has long used a similar formula with satisfactory results in computing wall thicknesses for pressure vessels as specified in the API-ASME code for unfired pressure vessels.

Several notes have been added to this edition of the code which apply to the pipe wall thickness formulas, permitting a broader interpretation of the requirements. Where pipe already is on hand and available for measuring the actual thicknesses and outside diameter, it is obvious that the measured dimensions can be inserted in the formula and the corresponding working pressure computed directly for any given service temperature. Where pipe is not yet available and has to be ordered from the mill or from jobbers' stock, the nominal wall thickness and diameter must be specified in a manner which will allow sufficient margin for underthickness and outside diameter tolerances in manufacture. Under these circumstances the pipe wall thickness formula can serve as a guide for design as noted in italics in item 3 of the third paragraph of the introduction, reading in part as follows:

> The code for pressure piping represents a standard of minimum safety requirements for: (1) the selection of suitable materials and reference to standard specifications by which they may be secured; (2) the designation of proper dimensional standards for the elements comprising piping systems; (3) *the design of the component parts as well as the assembled unit* including necessary supports; (4) the erection of these systems; and (5) the test of the elements before erection and of the completed systems after erection.

In determining what wall thickness or outside diameter to use in designing a pipe line, it manifestly is impossible to use in the formula the *actual* measured dimensions of pipe which has not yet been made and which is subject to manufacturing tolerances. Under these circumstances it is intended that the designer will compute by formula the minimum wall t_m required on inspection, using the S value of allowable stress for the material which corresponds to the expected service conditions. Then, in order to arrive at a *nominal* thickness to specify in ordering pipe, it is necessary to add the manufacturing tolerance to the computed minimum wall thickness so that, if the pipe comes out on the light side in rolling, the wall still will be heavy enough to satisfy the minimum requirements. Rather than specify special thicknesses in ordering pipe, which practice would be justified only on extremely large orders, it is customary to select a nominal thickness from some pipe schedule, such as ASA B36.10, so as to order the standard thickness next heavier than the minimum theoretically required. Variations in wall thickness permissible within the manufacturing tolerance for commercial pipe are illustrated in Fig. 1.

To provide for those cases where actual measurements of wall thickness and outside diameter can be made on pipe already rolled, a new note has been added to the paragraph on pipe wall thickness as follows:

> Where available from pipe on hand or in stock, the actual measured outside diameter and actual measured minimum wall thickness may be used to calculate the maximum internal service pressure.

Another new footnote for the same paragraph has been added to permit further latitude in computing the pressure for which a given length of pipe may be used. This is as follows:

> When computing the allowable pressure for a pipe of a definite minimum wall thickness, the value obtained by this formula may be rounded out to the next higher unit of 10.

Non-Ferrous Pipe and Tubing—Another feature of the pipe wall thickness formula which has occasioned considerable discussion since the first edition of the code involves the factor C for non-ferrous pipe and tubing. In the 1935 edition, plain end non-ferrous pipe or tubing for 1 in. size and smaller was assigned a C factor of 0.05 in., whereas for sizes larger than 1 in., the factor was 0.065. This must be added to the minimum thickness computed by the Barlow or Lamé formulas.

It was pointed out that the wall thicknesses so obtained were inconsistent with general usage of copper pipe or tubing. Where the latter is used on account of its greater flexibility, the increased thicknesses required by the code formula resulted in copper pipe too rigid for the service intended. Further, the code had always permitted seamless copper water tube in accordance with ASTM specification B88. The tables of thickness in that specification, which represent satisfactory commercial practice, were entirely inconsistent with the values of wall thickness computed with code formulas, using the allowances specified. In many cases, the corrosion allowance was equal to or greater than the corresponding commercial wall thickness, from which it might be concluded that the commercial tubing was unsuitable for service at any pressure.

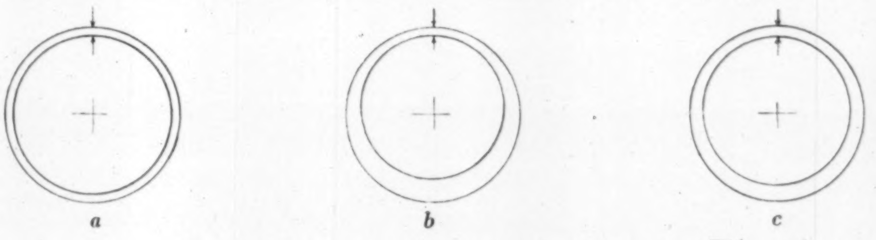


Fig. 1—Variation in wall thickness for seamless pipe

Left (a)—Concentric pipe having uniform minimum wall thickness (87½ per cent nominal). Such a condition would be unusual in rolling, hence the pipe would not be commercially obtainable.
Center (b)—Eccentric pipe having minimum wall thickness (87½ per cent nominal) on one side and overthickness on the other. With commercial pipe under extreme condition, one side could be about 25 per cent thicker than the other, and still meet specified tolerances. Since the minimum thickness may be encountered, design of pipe lines prior to receipt of the pipe must be based on this possibility.
Right (c)—Eccentric pipe having the thinnest point in the wall above the minimum specified. This is the condition in which pipe ordinarily is furnished. For pipe on hand or in stock, advantage may be taken of the actual measured outside diameter and minimum measured wall in computing the maximum allowable service pressure.

The matter was submitted for consideration of the sectional committee, which ruled that for non-ferrous pipe and tubing conveying the fluids permitted under the several code sections, corrosion in the majority of cases was a negligible factor. In the case of plain end non-ferrous pipe and tubing, therefore, a C factor of zero is assigned. To provide adequate mechanical strength, particularly in the smaller sizes, minimum wall thicknesses were specified, which vary between the individual sections in accordance with what is considered safe practice for the fluids conveyed. Also, the following sentence is included:

> Additional wall thickness shall be provided as required to care for corrosion, erosion, or mechanical strength.

These requirements correspond to those for non-ferrous pipe and tubing given in the ASME boiler construction code, which have been found through long usage to be entirely satisfactory.

Allowable Stress

In the 1935 edition of the code, no specific sanction for using higher allowable stresses in computing pipe wall thicknesses for service temperatures below 650 to 700 F was given for the power, gas and air, or district heating sections, although the oil section permitted such adjustment. In view of the decreased hazard involved in conveying fluids below 650 F and down to 150 F, it was decided to permit a lower factor of safety which is proportionate to the extent the temperature falls below 650 F. This permits correspondingly higher *S* values with the decreasing temperature. In the power section, for instance, a factor of safety of five is assigned at 650 F, and a factor of four at 150 F.

Other sections of the code have made similar provision for increased stresses at reduced temperatures except for the refrigeration section where the low temperatures involved require special attention to offset the brittleness inherent there in many materials.

Contrary to practice in the piping code, the ASME boiler code does not permit higher stresses for ferrous pipe materials operating at temperatures below 650 F. In the case of fittings (and valves by inference) both codes permit increased allowable pressures as the temperatures decrease, in accordance with the standard ratings designated in the American standard for steel pipe flanges and flanged fittings, ASA B16e. Where the temperature exceeds 650 F both codes require progressively decreasing working stresses, commensurate with the decreasing strength of the materials as the temperature rises. In the field of higher temperatures, the ASME boiler code committee and the piping code committee cooperated in setting *S* values for pipe so that the two codes would be in agreement on this vital point. The values for non-ferrous materials in the lower temperature bracket also will be made to agree in both codes. The new allowable stresses for many of the materials included have been changed from their previous values in order to keep abreast of the best existing knowledge of the properties of materials, particularly at the higher temperatures.

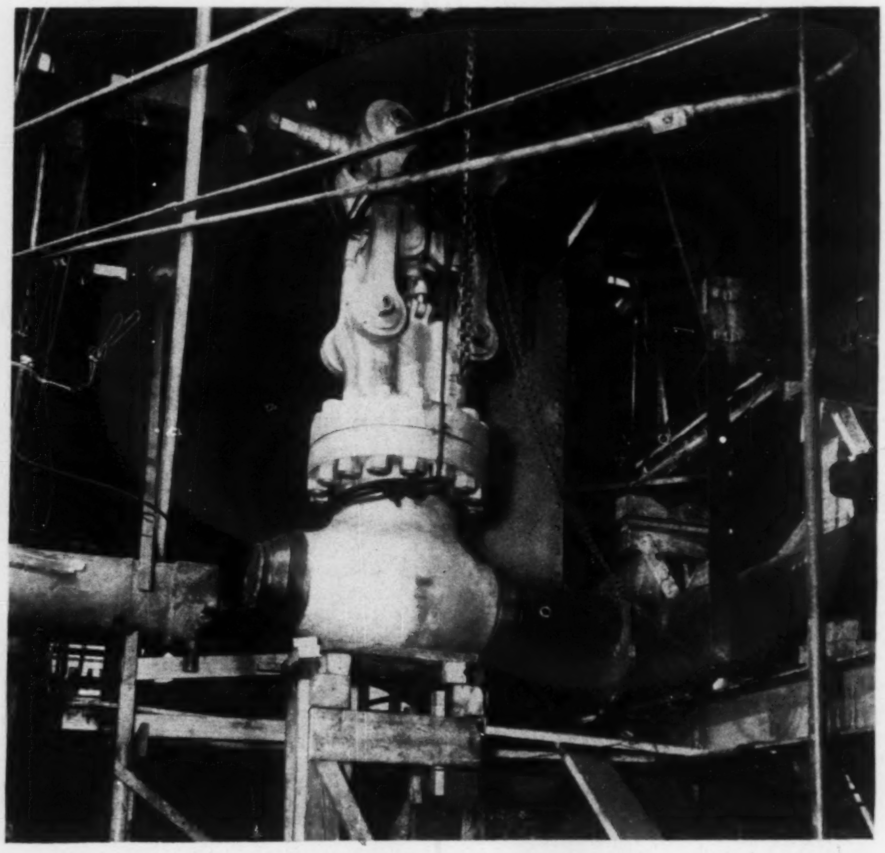
Welding Fittings

Welding as a means of fabricating and erecting pipe lines has developed rapidly since 1935 until, at the present time, few bolted joints are specified for pipe lines for high pressure, high temperature steam service. Valves for such service may now be obtained with welded instead of bolted bonnet joints, and this edition of the code specifically permits such construction. Where pipe must be disassembled frequently for inspection, as is the case with lines conveying high temperature oil, bolted joints necessarily are used to a greater extent.

The rapid adoption of welded pipe joints has been accompanied by a corresponding development of factory made welding fittings. These are made in a variety of forms such as elbows, tees, crosses, laterals, return bends, etc. An American standard, ASA B16.9, on steel butt welding fittings, has been developed and published, and another on steel socket welding fittings is in the process of being approved. Materials specifications to cover these products have been formulated by the American Society for Testing Materials, ASTM designations A216, A217 and A234. The first two cover castings, whereas the latter covers wrought fittings.

Widespread use of these fittings is recognized in the piping code in all sections something along the lines of the following, which is quoted from the power section:

> The dimensions, strength and marking of factory made welding fittings shall comply with American standard B16.9 for steel butt welding fittings, where applicable, and the material shall conform to ASTM specifications A216, A217 or A234. Special fittings or welded assemblies fabricated in shop or field shall conform to section 6 of this code. The material of special welding fittings shall conform to ASTM specifications A216, A217 or A234. For the purposes of this section, special fittings or welded assemblies shall be construed to embrace cast, forged, rolled or extruded fittings of special dimensions, and built-up manifolds, segmental elbows, fabricated swages,



Typical high pressure, high temperature valve designed for 1450 psi-925 F steam service. This is the non-return valve for No. 72 boiler at Waterside No. 2 Station of the Consolidated Edison Co. of New York. Note the welding ends. Made in alloy steel to the dimensions of the 1500 lb series of American standard B16e-1939, this valve with welding ends is rated as good for 1500 psi at 950 F

Humidity Control in UNDERGROUND BOMBPROOF SPACES

Edward Ledoux Stresses Importance of Wall Evaporation as Source of Moisture

***Bombproof Spaces*—It will be seen from Mr. Ledoux' discussion (of which this is the first part) that the lowering of relative humidity by heating is not applicable to underground bombproof spaces. In spaces where occupancy and the amount of heat evolved are nil or small, adiabatic operation can be achieved or approached. In such cases, adsorption appears to be the only system which will produce a low enough dew point. Furthermore, if the net heat of adsorption is dissipated outside the spaces, dehumidification is adiabatic so to speak. No cooling water is required. . . . In spaces where heat is evolved, the lowest operating temperature which can be maintained depends upon the amount of heat liberated and the amount of cooling water available. Effectively, the elimination of heat from the spaces using air as a carrier is prohibitive (particularly in the case of gasproof spaces) so that such elimination can only be carried out in two ways: through heat loss to the walls and by means of cooling water evacuated from the conditioning apparatus. The previous means increases wall evaporation, so that the latter should be used to the full limit of availability. The quantity and temperature of the cooling water are therefore major factors and usually the conditioning load will be greater than in the previous case. However, due to the higher operating temperature, the treated air dew point need not be as low. This will permit using the absorption process and even refrigeration when the unavoidable temperature rise is considerable. . . . Evidently, other circumstances than humidity and temperature may have to be considered when selecting the most appropriate conditioning system. Furthermore, in the case of bombproof spaces, the questions of first cost and operating cost are secondary to that of availability under wartime conditions of the necessary elements consumed by operation. Also, the choice of equipment depends upon whether the spaces are to be gasproof or not and upon the capacity of the auxiliary power plant, if any**

CONSTRUCTION FOR VICTORY

ONE of the main objects of military air force is to strike directly far into the rear of the enemy with the double purpose of destroying his most vital means of production, storage and communication and breaking down morale through bombardment of civilian and non-military objectives. This brings war to any area inside the belligerent countries, so that defense must extend to the entire territory and not be confined to the actual theater of military operations.

Protection of the nation against bombardment involves two distinct but indispensable means: (a) Active defense assured by a fighting air force supported by adequate anti-aircraft equipment, sufficient to reduce to a minimum enemy incursions. (b) Passive defense assured by bombproof construction. Provision for the latter includes putting underground manufacturing plants and stocks of raw material or finished products, and providing shelters for civilians and particularly industrial workers. Of course, the passive defense of many industries —such as blast furnaces, for instance—can hardly be contemplated. The active defense which must be reserved for their protection should be left available by passive defense of everything else of importance that is possible.

REMEMBER PEARL HARBOR!

Main Factors

The design, construction and equipment of underground spaces are evidently subject to many factors and considerations; some are specific for different spaces while others apply to all types of construction. Among the latter is the necessity for humidity control, although the suitable apparatus used will depend upon the type of spaces considered.

Due to the tremendous heat capacity of the extra thick masonry and surrounding ground, which acts as a powerful thermal regulator, the temperature in unconditioned underground spaces at adequate bombproof depth will remain almost constant throughout the year, while the air will practically always be saturated and often supersaturated with fog. The natural constant temperature being low (50 to 60 F in temperate zones), this saturated atmosphere, which is already hard on people whose occupations require constant presence in the space, is even more dangerous for persons who are called upon to enter and leave frequently. Condensation will furthermore cause great damage to equipment and material in such spaces.

The sources of high humidity in underground spaces are both external and internal. They include opening of doors and leakage, humidity given off by the people present, humidity brought in through ventilation requirements, evaporation of water in bulk, and masonry porosity.

Of these various sources, that due to masonry porosity is always one of the major ones to be contended with and, in many instances, all the others become negligible by comparison.

Wall Evaporation

Building materials used in the construction of underground spaces are always pervious to humidity so that, in spite of the considerable thickness provided to resist bombardment, water will always seep through by capillarity to a variable orange peel bull plugs or any similar construction not covered by American standard B16.9 for factory made welding fittings.

The latter part of this paragraph refers to "special fittings" or "welded assemblies" fabricated in shop or field. These represent more or less special designs which have not been fabricated in accordance with the requirements of the American standards covering factory made fittings. Welded joints of such special designs must conform to the requirements of chapter 4, section 6 on welding of pipe joints, and if applicable, the rules of chapter 5, section 6 on welded branch connections and fabricated or cast specials shall apply as well.

Bolting

More severe service conditions have necessitated more exacting requirements for bolting where it cannot be replaced by welded construction. In those sections applicable to temperatures in excess of 750 F, bolting is specified to be in conformity with ASTM specification A193 covering alloy steel bolting for temperatures from 750 to 1100 F. For temperatures below 750 F and pressures in excess of 250 to 300 psi, bolting in accordance with ASTM specification A96 is permitted. For less severe conditions, carbon steel bolts in accordance with ASTM specification A107, grade 22 or better, may be used, the same as in the previous edition. Bolts or bolt studs with reduced shanks or threaded full length are permitted in addition to the usual end threaded bolt studs.

In the previous edition, carbon steel headed bolts were required to have dimensions in accordance with the "heavy series" of the American standard for wrench head bolts and nuts, ASA B18.2. This requirement is occasioned primarily because of the long established trade practice of having all bolt holes ⅛ in. larger than the bolts. As a result the regular series hex nuts, and to some extent the square heads of headed bolts, tend to chew into the bolt holes rather than to ride securely on the face of the flange. A further reason for using the heavy series bolt heads and nuts is to afford a better wrench grip for pulling the bolts up as tightly as is necessary in pipe joints.

In using square headed bolts of heavy dimensions with cast iron flanges, however, some interference was found with fillets on the back of the flanges. Machining off the fillets was undesirable since the flanges were weakened and points of high stress concentration resulted. It was agreed, therefore, to permit use of "regular series" square heads on carbon steel bolts since it would be impractical to demand a redesign of all fittings even though the "heavy series" bolt head dimensions are considered more suitable for bolts for piping work. Where heavy series heads are wanted for this application the hexagonal rather than square shape should be used. Heavy series hexagonal nuts continue to be required in all cases.

The above revisions constitute the more important changes common to all code sections. Future installments of this series of articles will undertake to develop changes which have been effected in the individual sections pertaining only to the fluids covered in the respective section.

The Priorities Picture . . .

Repair, maintenance and operating supplies—A new order which helps many thousands of manufacturers and producing plants to obtain repair, maintenance and operating supplies was announced December 18 by the division of priorities of the Office of Production Management. The new order is known as preference rating order P-100. It takes the place of the old repair and maintenance order, P-22, which is being revoked.

Main purpose of the new order, as was the case with the old, is to extend priority assistance to manufacturers and producers so that they can keep their plants and production machinery in good running order. This is in accordance with the policy set by the Supply Priorities and Allocations Board.

The differences between P-100 and P-22 are largely technical. However, some provisions of the old plan have been liberalized and a number of clarifications have been made in order to eliminate misunderstandings and misapplications of the order which occurred in the past.

The assistance granted by the order is not available for retail operations. It is available, however, to the following:

1) Any governmental unit.

2) Any individual, partnership, association, corporation or other form of enterprise engaged in one or more of the following capacities to the extent that it is so engaged or so acts:

a) Manufacturing, processing or fabricating.

b) Warehousing—maintaining warehouses for storage or distribution of any material.

c) Wholesaling—acting as a distributor of products sold to manufacturers, wholesalers, retailers or other persons not consumers.

d) Charitable institutions—any charitable or eleemosynary institution which is recognized as such for purposes of the internal revenue laws of the United States.

e) Carriers—urban, suburban, and interurban common or contract carriers of passengers or freight by electric railway, electric coach, motor truck or bus, including terminals of any of the foregoing: railroads, including terminals; shipping—commercial carriers of freight and passengers by ocean, lake, river or canal, including terminals.

f) Educational institutions (including vocational training).

g) Printers and publishers.

h) Radio—commercial broadcasting and communication.

i) Telephone and telegraph communication, including wire services.

j) Hospitals, clinics and sanitoriums.

k) Petroleum and natural gas—discovery, development and depletion of pools of petroleum and associated hydrocarbons and derivatives thereof, and transportation of petroleum, associated hydrocarbons and derivatives thereof.

l) Irrigation systems, whether publicly or privately owned; toll bridges and toll canals.

3) Any person using tools or equipment to repair or maintain the property of any producer as defined in the order.

P-100, like the former P-22, continues the policy of protecting the health of the nation and maintaining necessary services for its businesses and institutions.

The former restriction on acceptance of materials for inventory of maintenance, repair or operating supplies by producers using the order has been changed to permit inventory and stores not exceeding 110 per cent of the maximum dollar volume of such materials purchased during the corresponding calendar quarter of 1940. The previous figure was 100 per cent. This change has been made to allow for price increases. However, the order now specifically states that no materials may be accepted for additions to inventories and stores of maintenance, repair and operating supplies until such inventories have been reduced to a working minimum.

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extent according to the material and the nature of the ground.

The humidity which reaches the inside surfaces of the walls, ceiling and floor through capillarity *is not visible and cannot be detected through mere inspection of the surface* (actual visible leaks are included in the previously mentioned item "water in bulk").

The vapor pressure of this invisible water is the saturated vapor pressure corresponding to its temperature, which is that of the surface layer of masonry. If the spaces are not conditioned, the air is saturated and its temperature is the same as that of the walls; no difference in vapor pressure exists between air and walls so that initially—that is to say, at the starting up of the conditioning apparatus—there is no surface evaporation. As conditioning proceeds, however, and the relative humidity is reduced, surface evaporation will increase rapidly.

Precautions

Of course, the amount of capillary water to be contended with by the air conditioning engineer depends to a very great extent upon the construction of the spaces. Construction details can do so much to lighten the conditioning load that it is not without interest at this point to enumerate briefly the effective means.

Evidently, the degree of porosity depends primarily upon the kind of material employed and the reduction in the amount of humidity from this cause through the use of special waterproof concrete will well justify the extra cost.

An extremely effective measure is to provide double walls and ceiling with an air space between the inner wall and the main structure, the inner space being properly drained for drippings. A design which will give good return for the capital invested is to build the main structure with ordinary concrete and the thin inner wall with high grade impervious material. The dead air space should never, of course, be used for

"Protection against enemy bombardment involves active defense by a fighting air force supported by anti-aircraft equipment, and passive defense assured by bombproof construction"

THE AUTHOR ....

. . . was until last year chief engineer of a French firm engaged in air conditioning engineering, particularly with adsorbents. Although many varied problems for the army and navy were handled and solved, most of the firm's activity after 1931 was concerned with bombproof shelters, storerooms, forts and factories.

The necessity for humidity control in underground spaces was imposed by the considerable deterioration of equipment or supplies and numerous cases of pneumonia among men manning forts or servicing storerooms; dormitories in forts could not always be occupied steadily as they were meant to be. At first, no one had any idea either of the order of magnitude of the capacities required or of the most adequate means; wall evaporation was not suspected because the walls looked dry. The bulk of the present discussion bears on wall evaporation. This is intentional because it has been the author's experience that this source of humidity is always underestimated, if not disregarded entirely. The article stresses the importance of this factor and how to cope with it; other sources of humidity are merely mentioned because their handling is just usual air conditioning.

ventilation except for exhaust purposes.

An adequate asphaltic base lining on the outside face of the main structure will reduce the amount of water which will penetrate the masonry; it should be noted, however, that such a lining must be perfect and remain so, a very difficult thing to obtain in practice—particularly if the construction is tunnelled. When a double wall is provided, a lining of this sort on the outside face of the thin wall is most effective.

Properly drained loose rock backfill outside the main structure will effectively reduce hydrostatic pressure.

The anchoring of structural steel in the main structure should be avoided whenever possible and such equipment as overhead cranes, storage racks, duct work and so forth should rest on columns independent of the walls. Points of anchorage are practically always a source of trouble.

It is hardly necessary to point out the importance of proper drainage design inside the spaces.

Temperature

Since evaporation increases with the vapor pressure at the surface (all other conditions remaining the same), it is imperative to keep the temperature of the damp walls as low as possible by communicating no heat to them; or, better still, by cooling them if this is feasible. The wet bulb temperature of the conditioned air must therefore be equal to or lower than the initial natural temperature of the spaces. Considering that the latter is quite low, this means that the conditioning must be carried out at low temperature. Another reason for low temperature operation is that, for a given reduction in relative humidity, the vapor pressure difference and therefore the evaporation are then smaller.

Dew Point

On the other hand, the lower the operating temperature, the dryer the conditioned air must be if reasonable flows are to be used, the coefficient of evaporation reduced to a minimum, and positive reduction in humidity achieved.

The moisture removal from the spaces being proportionate to the difference between inlet and outlet humidities, the treated air dew point not only controls the rapidity of action of the conditioning equipment but also the theoretical and actual maximum possible humidity lowering for a given flow.

In the case of storage rooms where low temperature operation is possible, the dew point must necessarily be extremely low, since even at saturation the *absolute* humidity in the spaces is low.

In the case of factories where low temperature operation is not possible on account of the considerable amount of heat liberated inside the spaces, the dew point may be higher than in the previous case and still give satisfactory results.

The most economical system of ventilation is of course the closed circuit, which is applicable to storerooms. With this system, the plant capacity decreases continuously as conditioning proceeds due to the gradual reduction in absolute humidity at the plant intake; simultaneously, as already stated, the wall evaporation increases so that there comes a time when the capacity is no longer superior to evaporation and the humidity in the spaces cannot be further reduced. It will be seen that the per cent capacity drop is also a direct function of the treated air dew point. In the case of underground storerooms, the dehydration equipment must deliver air at about 0.0015 lb moisture per lb of air to get any results.

[*A second article by Mr. Ledoux will present equations and charts developing design details for humidity control in underground bombproof spaces.*]

Priorities . . .

Small orders—Because of the outbreak of war and the need for speeding up production, the OPM division of priorities last month moved to streamline and simplify regulations governing the extension of preference ratings on orders involving less than $500 worth of material. Such orders amount to approximately 60 per cent of the total number of extensions handled in the field by the army and navy contracting officers, although these small orders amount to only about 2 per cent of the total dollar value covered by all certificates. Under the new system, a manufacturer who wants to extend an army or navy preference rating to obtain material valued at less than $500 may attend to the extension himself, without the necessity of having a contracting officer go through the previous routine requirements. This new streamlining privilege, however, may be used only if the material to be obtained with the rating is to be physically incorporated in the finished product covered by the certificate being extended.

Copper—Due to increased activity which the present war effort is requiring of all officials in government, industry and labor groups, SPAB decided that the information it had requested regarding copper production can be obtained more quickly if public hearings are dispensed with. Accordingly, it requested that Chester Davis, impartial chairman named by OPM to conduct the inquiry, obtain written statements from all persons who have suggestions as to ways in which copper production can be increased, and that he then analyze these and submit his findings to SPAB for such action as may be indicated.

INDUSTRY COMMITTEE PRESENTS REPORT ON "FREON" REFRIGERANTS TO THE OPM

Minimum Amount of "Freon" This Year Is 13,400,000 Pounds, Requiring 17 Per Cent of the Available Carbon Tetrachloride

A COMPREHENSIVE report on "Freon" refrigerants, which are on the OPM critical list and are controlled by general preference orders M-28 and M-41, was submitted December 9 by subcommittee No. 8 (miscellaneous reference) of the air conditioning and refrigeration industry committee to various OPM and other officials.

Members of this subcommittee are F. H. Faust, discussion leader, J. A. Bentley, E. G. Biechler, Charles J. Hall, F. J. Hood, George S. Jones, Robert LeBaron, M. G. Munce, Frank R. Pierce, Frank K. Smith, R. J. Thompson and C. E. Wilson.

The investigation was made at the request of the Office of Production Management and contains the following: a general review of the characteristics of refrigerants required by the air conditioning and refrigeration industry; a summary of codes and standards; technical considerations pertaining to the application of refrigerants; results of a questionnaire to determine the extent of possible substitutes for "Freon"; and an analysis of the amount of "Freon" required in the air conditioning and refrigeration industry in 1942. The report points out that certain economies can be made in the use of "Freon" and that, furthermore, the requirements can be reduced if necessary by curtailment of production of non-essential air conditioning and refrigerating equipment. Substitutes, principally sulphur dioxide and methyl chloride, can be used to a limited degree, but the report indicates conclusively that no general substitution program is possible.

The absolute minimum amount of "Freon" for 1942, taking into consideration curtailment of the industry and economies of use and substitution, is 13,400,000 lb, which would require 18,700,000 lb of carbon tetrachloride. This is approximately 17 per cent of the available supply. This minimum is based on maintenance of existing equipment and the supply of refrigerants in new equipment for defense usage and essential civilian uses only. It would be desirable to increase this absolute minimum to 15,600,000 lb of "Freon", which would require 21,800,000 lb of carbon tetrachloride, according to the subcommittee.

Recommendations

In its comprehensive report, the subcommittee recommends that:

a) A "Freon" conservation program be adopted to prevent unnecessary waste and to promote economical use by means of educational literature sent to field and factory organizations.

b) Limited substitution in new equipment of sulphur dioxide and methyl chloride should be encouraged where limitations of application, safety, cost and time permit. In this respect governmental purchasing agencies should permit use of these substitutes in equipment where such use is satisfactory from the application and safety standpoint.

c) General substitution of sulphur dioxide and methyl chloride for the "Freon" refrigerants should not be required because:

1) The cost of a general redesign is excessive (from 15 to 20 million dollars).

2) The time required for general redesign is lengthy (from 1½ to 3 years).

3) Tooling facilities are tied up on defense work.

d) A supply of carbon tetrachloride must be made available to satisfy at least the minimum requirements for "Freon-11" and "Freon-12" manufacture. As pointed out in the October 22, 1941, report of subcommittee No. 4, "a large part of this industry's production is devoted to essential uses for the basic life of the country. In wartime these essential civilian uses are the foundation of the defense program itself." [For report of subcommittee No. 4, see HPAC, November, 1941, pp. 693-696.]

To satisfy probable requirements in 1942 only 17.0 per cent of total carbon tetrachloride production is needed for "Freon-11" and "Freon-12".

e) Allocations of carbon tetrachloride for the manufacture of "Freon-11" and "Freon-12" refrig-

ONE RESULT of our all-out war effort and the defense program which preceded it is that American industry has been and is taking a good look at itself—in some cases, for the first time. Judging by the first two of its subcommittees to present reports, the air conditioning and refrigeration industry committee is doing an outstanding job in this respect. . . . Subcommittee No. 4—priorities, ratings, and allocations—presented its report to the Office of Production Management on October 22; this report was summarized in the November HPAC. The equally thorough report of subcommittee No. 8—miscellaneous reference—which was submitted December 9 is abstracted here. Particularly important to the reader is the tabulation of what can be done to conserve the essential "Freon" refrigerants

CONSERVATION
FOR VICTORY

WHAT YOU CAN DO

PROGRAM FOR THE
CONSERVATION OF "FREON-11", 'FREON-12" AND "FREON-114"
IN THE
AIR CONDITIONING AND REFRIGERATION INDUSTRY

A voluntary effort on the part of manufacturers, sales and engineering agencies, and installation and service organizations to promote the economic use of "Freon-11," "Freon-12" and "Freon-114" is essential and can be accomplished. The following are specific actions that can be taken to promote this program:

Equipment Manufacturer

1) Elimination of losses and salvaging of refrigerant from laboratory test set-ups.

2) Elimination of losses and salvaging of refrigerant from production routine testing and run-in.

3) Lowering of refrigerant level in condensing unit liquid receivers by means of special designed liquid outlets which eliminate "vortex action."

4) Reduce amount of recommended refrigerant charge to minimum.

5) Reduce recommended sizes of liquid and suction lines to minimum. (This will also save copper.)

6) Reduce size of liquid line strainer (filter) to minimum.

7) Salvage refrigerant from apparatus returned for repair.

8) Contaminated refrigerant can be distilled and salvaged.

Sales Engineering and Specifications

1) Specify exact, minimum refrigerant charge on all installations.

2) Avoid use of evaporators requiring large refrigerant charges. Instead, wherever possible, specify use of compact forced convection type unit. Change from flooded evaporators to dry evaporators.

3) Lay out system for shortest possible length of liquid and suction lines.

4) Specify minimum recommended sizes of liquid and suction lines.

5) Increase insulation thickness on large jobs, thereby reducing size of equipment and refrigerant requirements.

Installation and Service

1) Check all joints and points of possible leakage with halide torch. It takes time, care and patience to find small leaks.

2) Do not recharge a system unless the leak has been found and repaired. This may cost more for that particular service call but in the long run it costs the customer less.

3) Weigh in exact charge of refrigerant as specified. Do not guess—use the minimum charge required.

4) The use of a sight glass (bull's-eye) in the liquid line, gives a visual means of charging the minimum amount of refrigerant required.

5) Unless otherwise desired, put condensing unit as near fixture as possible, so as to cut down length of installation lines.

6) Discontinue practice of blowing out evaporators, lines, etc., with refrigerant. Use another medium such as dry air, nitrogen or carbon dioxide.

7) Exercise care in purging air from condenser; a lot of refrigerant can be saved in this procedure.

8) Exhaust and reclaim refrigerant from systems to be replaced or repaired.

9) Exhaust and reclaim refrigerant from *supposedly empty* refrigerant drums or service cylinders.

10) Keep a close check on refrigerant stocks and amount charged into new or existing systems.

11) Pump down and lock refrigerant charge of all seasonal operation jobs (air conditioning, etc.) in liquid receiver. Carefully check system for leaks before releasing liquid and resuming operation at beginning of season.

12) Use regular size dehydrator (dryer) during installation period. However, if permanent dryer is desired, replace above with minimum size feasible.

13) Return empty refrigerant cylinders to manufacturer or supplier as soon as possible.

14) Service cylinder fittings, valves and connections should be replaced when worn or damaged. They should be protected when not in use

15) Replace all leaky shaft seals and gaskets on compressors.

Equipment Users with Own Service Organization

1) Observe recommendations given under "Installation and Service."

2) On seasonal operating jobs (air conditioning, etc.) it may be possible to borrow refrigerant to handle emergency service of other jobs. This would help the industry during the present shortage. The refrigerant could be replaced when larger stocks are made available.

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erants should be granted on the basis of at least the following minimum requirements, with consideration for the probable requirements:

	"Freon-11" and "Freon-12" Pounds	*Carbon Tetrachloride* Pounds
Minimum	13,358,000	18,700,000
Probable	15,568,000	21,800,000

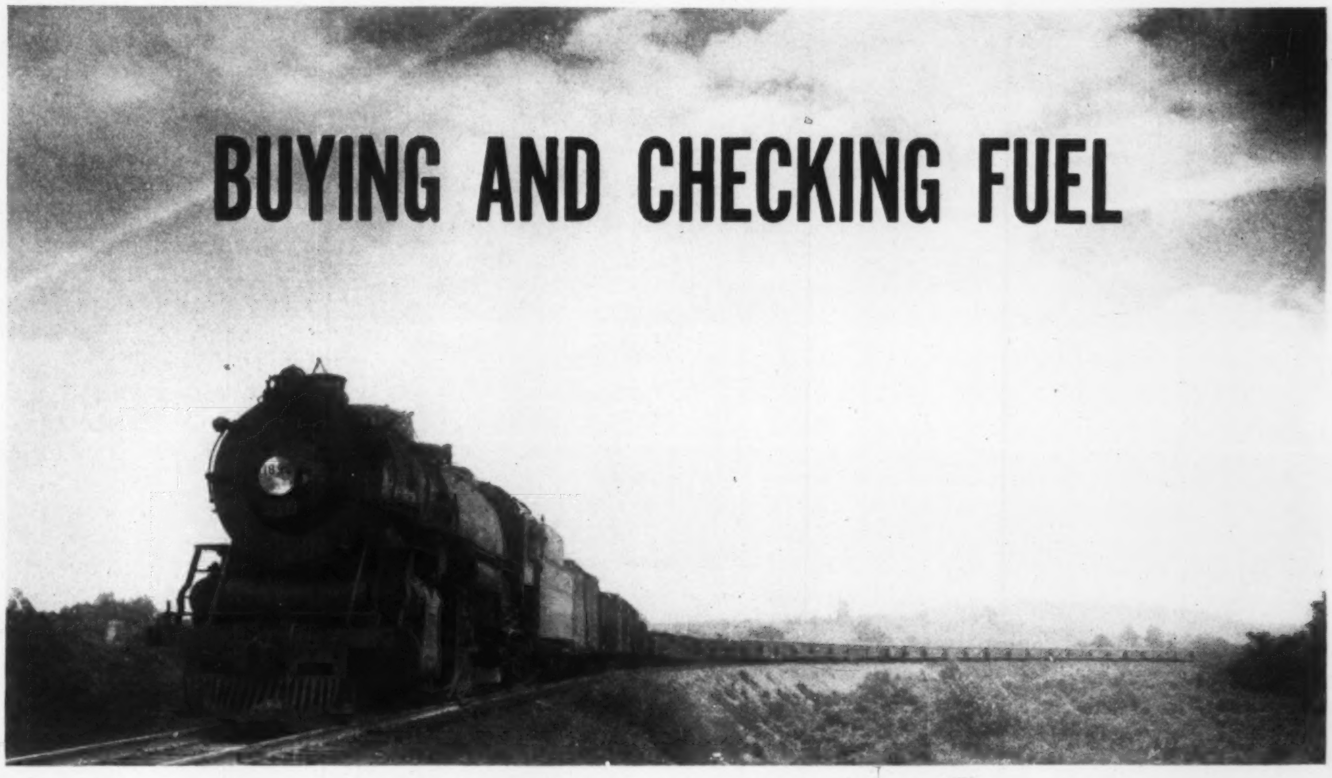
The probable requirement for 1942 is greater than past years because of the cumulative effect of increasing numbers of new systems requiring refrigerant for maintenance and because of the increased usage in the national defense program. The minimum figures are based on the suggested curtailment program outlined in the October 22, 1941, report of subcommittee No. 4.

f) General preference orders Nos. M-28 and M-41 as well as the civilian allocation program for chlorinated hydrocarbon refrigerants should be reviewed in the light of the above.

g) Although "Freon-11" and "Freon-12" have received prominence in this report because of the need for carbon tetrachloride in their manufacture and because together they are used to greater extent than others of the "Freon" group, consideration must be given to the others, particularly "Freon-114" which is used in domestic refrigerators, but which does not require carbon tetrachloride; lack of "Freon-114" will have the same effect on equipment using it as does the lack of "Freon-11" and "Freon-12" discussed in this report.

REMEMBER PEARL HARBOR!

BUYING AND CHECKING FUEL



New Procedure Used by Building Management Firm Provides for Guaranteed Heat Content and Definite Penalties for Poor Performance

By R. E. Hieronymus

FUEL purchases represent a major item in the average plant or building — in office buildings, for example, fuel for heating represents the largest amount paid for any commodity, after electricity. It is therefore important to economical and efficient operation and management that the most suitable fuel be used — particularly is this true now because of the need for conservation of everything possible for war production. . . . The right fuel for a plant or building may change from time to time with changes in cost of coal, oil and gas and with other factors. The basic figure to be used in selecting a fuel, or contemplating a change, is the Btu's which may be bought for one cent. . . . Because routine analyses of coal used in 11 buildings during one year showed 88 per cent to be of a lower Btu content than represented and only 12 per cent higher than represented, Mr. Hieronymus now uses a contract form which provides for guaranteed heating value of coal, with provisions for testing and penalties for poor performance. The method is described here and a sample contract form is reproduced. . . . The author, a member of HPAC's board of consulting and contributing editors, is general superintendent of Aldis & Co., large Chicago building management firm

IN localities where there are several available types of fuel for heating, the operating personnel of a plant or building should keep track of the relative values and suitability of the various fuels, and be prepared to choose the most economical. In districts where there is normally only one most economical fuel available (that is, in the oil or gas districts remote from coal, or in the coal districts remote from oil and gas) the possibility of alternate, more economical fuels must still be kept in mind. The same should apply continually where purchased steam is used or available, whether from a public utility or from a neighboring building.

What was once determined as good practice—or perhaps adopted long ago without adequate study as the expedient thing to do—may have become uneconomical. For example, in Chicago—for many years a coal burning district — the economical generation of steam was changed in some plants a few years ago due to the introduction of low rate, offpeak gas contracts, and by the development and availability of low grade (bunker C) fuel oils. As a consequence, a number of heating plants were converted from coal to fuel oil and to offpeak gas burning. More recently, on account of the national emergency and the threatened shortage of oil, fuel oil prices have risen more than coal prices, and the relative positions of the two fuels have changed somewhat.

Btu's for One Cent

While the choice of fuel is subject to considerations other than the number of Btu's available for one cent, this consideration is a most important factor. It is possible to determine (or predict) rather accurately the labor cost and other costs incurred in burning different fuels. These should all be weighed in the determination, and attention given to the probable continued availability of any new fuel under consideration. Only after determining all these is it possible to decide wisely whether or not to change the combustion equipment from one type of fuel to another; as, for example, from coal to oil or gas.

In our office we keep a chart, very simple to make, which shows for a given set of market conditions the relative economy of different fuels. From time to time as new gas rates are put into effect, or as new satisfactory fuels become available in the Chicago district, we revise the chart and when any new alternate fuel shows promise of being commercially preferable, we are prepared to consider changing our plants to accommodate them. The form of the chart is illustrated on the next page.

In the chart, it will be seen that certain assumptions are made with respect to the recoverable heating value in the fuels, and that the cost of firing them is deducted from the apparent values so that the resultant net values may be compared easily. The actual amount of the deductions for combustion efficiency, cost of firing, etc., on the chart may not apply in all districts or in all buildings, but those shown will serve as a guide to the method.

Equipment Converted

When a more attractive fuel appears, the cost of converting the equipment to its use is studied, and if the required investment can with certainty be satisfactorily amortized during the probable period of availability of the particular fuel, the plant is changed over, provided the necessary funds are forthcoming to make the change.

To illustrate the necessity of keeping abreast with these changes, in which process the chart has proved helpful, some of the changes made in our plants during the last few years have included the following:

In two new small buildings built on a taxpayer basis, purchased steam was chosen as the heating medium in preference to boiler plants.

Sixteen underfeed coal stokers have been installed, mainly to replace hand firing of coal.

In 1930, two oil burning equipments were discontinued in favor of stoker equipment. Subsequently, when the screenings market rose because of the large number of stokers installed in the district, and when bunker C fuel oil became available at a price designed to create a market for it, the practice of burning oil in these two units was resumed, using new burners adapted for the purpose. After two years of economical operation on this basis, the changes in fuel costs due to the alleged scarcity of oil caused us to change again to stoker operation, the cost of the oil burners having been amortized from savings in the meantime.

Several gas water heating systems were installed to take advantage of the unusually favorable non-winter gas rate available since the advent of natural gas into the Chicago metropolitan district.

Buying Coal

After electricity, which is the No. 1 commodity purchase in the average office building, the fuel bill for heating is the largest amount paid for any physical commodity. The metering and sale of electricity is well developed in commercial practice and ordinarily closely regulated by law for the protection of the purchaser. The same is not so true in the case of fuels, particularly coal.

The means are available for intelligent and accurate buying of coal, but it has been my observation that few office building or small plant users of coal have the knowledge or the initiative to use them properly. Partly on account of this condition, there has grown up in the coal business a group of adjectives and phrases which impress and intrigue the customer without at all protecting his pocketbook. "A strong piece of coal", "quality coal", coal from a "hot seam", etc., are intriguing designations, but even when attached to a modest looking ton price they may still not mean a sound purchase.

CONSERVATION
FOR VICTORY

In the buying of coal, where known coals are involved — i.e., fuels which can satisfactorily be burned in the purchaser's equipment —there are two main questions to be answered: (1) What is the heating value of the fuel (in Btu per lb as received)?; and (2) What is the price per ton? With this information, and with the means to insure that the coal lives up to the representations, the buyer is able to choose wisely between different coals and different dealers.

The frequency with which coal salesmen are unable to state the Btu content of their coal is surprising, but it is more surprising still that not infrequently when they are seeking to close contracts early in the contracting season, they are unable even to state the price. In some localities and with some types of sales, coal dealers use the "posted price" or the "published price" system, the proposal being governed by the current price at the time of signing the contract, and by the "posted price" as later published in some commercial journal or circulated among the dealers. Along with insistence on sustained quality in the fuel contracted for, the buyer should insist on a firm price throughout the heating season. In normal times a firm price contract can usually be made, though at present, on account of the uncertainties of the coal business and of the times, there is good reason for the dealer to avoid such contracts when possible. It is my understanding that in the large cities the "published price" is the price the dealers would like to get, not necessarily the price at which their goods are going to be sold. It is an artificial standard to point at, and may be substantially higher than the true market price.

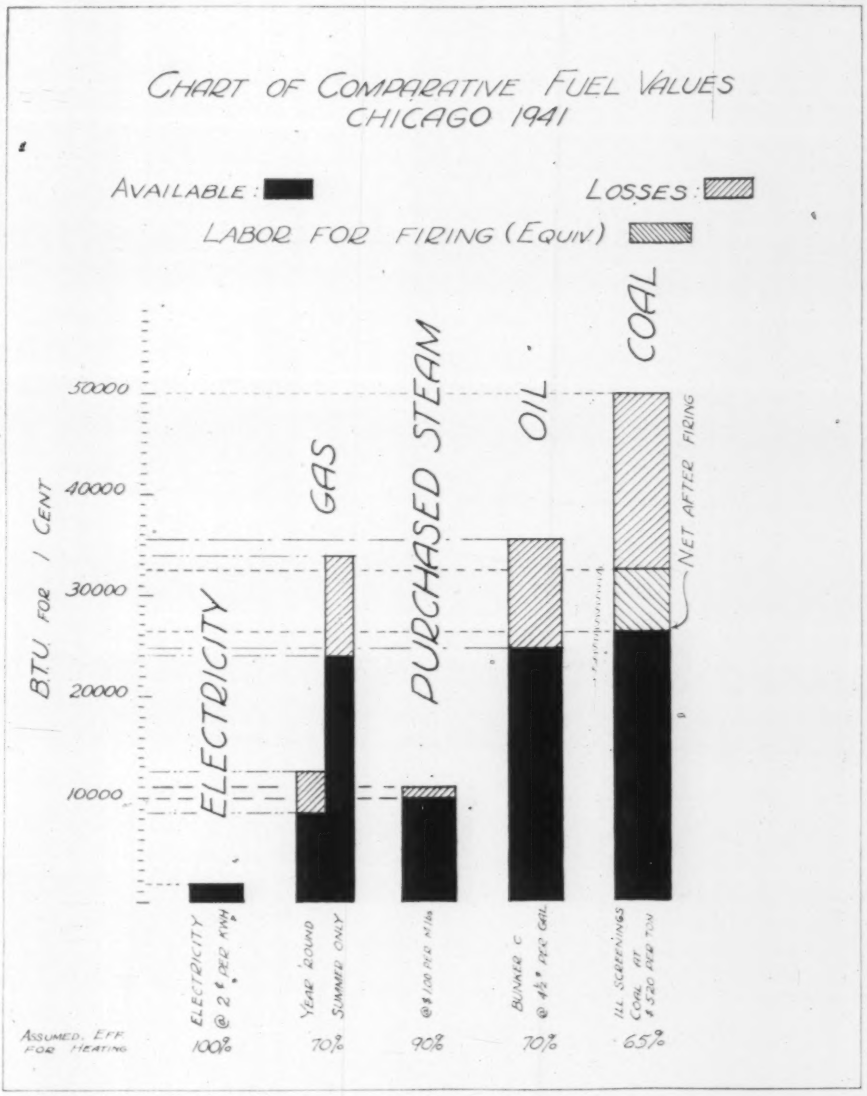
Optimistic Btu Values

Over-optimism as to the Btu content of coal has frequently been nothing short of shameful. In a recent experience, before guaranteed contracts were used, working with a half-dozen dealers fully conversant with the checking methods of our office and all having claimed familiarity with their fuels, rather distressing shortcomings were found.

Taking all routine analyses of coal made in the preceding year in 11 buildings, 88 per cent of the bin analyses showed a lower Btu content than represented, and only 12 per cent showed greater values. Those tests indicating less than the represented values showed the fuels to contain 94.17 per cent as many Btu's as represented, and those testing higher showed only 101.13 per cent. Averaging *all* tests, the fuels proved only 94.97 per cent as good as represented. The poorest and the best showed, respectively, 85.7 per cent and 101.8 per cent of the represented heating value.

All of these heating values, both those represented and those determined as actual, were on the basis of Btu as received, and all emphasis placed on dry basis analyses fell on our deaf ears. There seems to be little reason why a purchaser should ever see a dry analysis on any fuel—it is bought, delivered and burned on an as received basis and representations and claims for excellence on the dry basis are therefore largely academic.

I recognize the difficulties of controlling the quality of fuel and the means of performing the guarantee or representation. Care in preparation, substitution of fuel from a different vein or field, time in transit and storage, exposure to the weather during transit and storage—all are factors not completely under the control of the dealer, and some of them may change the heating value of the fuel between the time it is mined and the time it is delivered into the consumer's bin. All of these hazards, however, are constantly present in some degree or other and the dealer should shortly learn their probable effect and should make allowances for them in his representation of quality. The test of his attention to these variables and the faithfulness of his representation may be found in the average results of the laboratory tests. With representations honestly made by the producer and with allowances for depreciation intelligently applied by the dealer, the analyses made by the consumer should spread evently above and below the represented figure, and no variation so large as 14 per cent should ever be encountered, it seems to me.



The indiscriminate use of the word "represented" in the foregoing was intentional, for up to this point our fuel purchasing had not been on a "guaranteed" basis. However, for the average dealer the margin between "represented" and "guaranteed" is a very narrow one and the highly reputable dealer will, if required, make the terms synonymous; that is, he will *guarantee* that the fuel delivered will be *as represented* at the time the contract was made, and will be willing to make adjustments in case of gross inferiority.

To weigh a bag of cement, to measure the quantity of lumber, to count the number of bricks in a consignment, are simple matters. To check the heating units in a ton of coal—while it can be done in a laboratory maintained by the purchaser—is not so simple a matter and, except in the case of consumers utilizing many thousands of tons of fuel each year, is not practicable. There exist, however, in all large cities—and there are available elsewhere—commercial laboratories where samples may be analyzed at a modest expense. Only through laboratory analyses can the purchaser really judge the performance of his fuel contract.

In recent years the bidding of fuels has been greatly complicated, first by the endeavors of the NRA to impose price structures on the industry in 1933, and more latterly by the Guffey-Vinson bill, the full effect of which on the fuel industry is yet to be determined. While neither of the programs was designed to impose conservatism on the producers or the dealers in fuels,

THE DE LUXE COAL CO.
COAL CONTRACT

Chicago, Ill.
........(date)

Star Management Co.
Chicago, Ill.
Gentlemen:

In connection with our proposal for fuel for the Excelsior Building, during the heating season of 1940 to 1941, in which we have represented the As Received value of the coal as 12,500 Btu per pound, we agree to be governed by the procedure set out below, which becomes a part of our proposal as though written in the original document:

(1) Our proposal referred to above offers you Franklin County 1¼" dedusted screenings Coal having an average heating value of 12,500 Btu per pound, at the price of $5.00 per ton; the heating value for one cent being 2000 × 12,500 ÷ 500 = 50,000 Btu's. It is the intent of our proposal to furnish you this amount of heat units for each one cent of the contract price, and the performance of our contract shall be upon this basis.

(2) You are free to have commercial laboratory analyses made on the coal from your bin, up to the number indicated in the next paragraph, and the results of these analyses will determine the performance of our contract.

(3) Analyses governed by this agreement may be made at intervals determined by the Star Management Co., but there shall not be made more than one analysis for each 10 tons of coal purchased during the season; and, insofar as it is practicable to determine it, not more than one analysis shall be made for any 10 ton load.

(4) It is agreed that the Expert Analyzing Co. of Chicago shall be used for the work of analysis.

(5) It is agreed, to assure the fairness of this contract, that the purchaser, the Star Management Co., will not wet the coal in the bin, by the use of either water or steam.

(6) The method of sampling and of conducting the analysis shall be the method in common use at the laboratory of the Expert Analyzing Co., being the method prescribed by the American Society for Testing Materials.

(7) Duplicate reports of the analyses, accompanied by bill for same in the amount of $8.00, will be transmitted by mail to the Star Management Co. A duplicate of the test results will be transmitted to the coal dealer.

(8) In any test when the Btu per pound As Received is higher than the figure represented in our proposal and accepted by the Star Management Co. as the basis of contract, the Star Management Co. will pay the cost of the test.

(9) In any test where the Btu per pound As Received is less than the represented figure, the coal company, undersigned, agrees to pay the cost of the test within 10 days, direct to the Expert Analyzing Co. (When this is the case, the bill for testing will be transmitted to the dealer with the duplicate laboratory report.)

(10) The DeLuxe Coal Co., undersigned, agrees that when the test result shows the coal to be more than 2 per cent inferior in heating value to the figure represented, on a Btu As Received basis, he will credit the Star Management Co. a proportionate amount for 10 tons of coal. This credit will be extended by a credit memorandum at once and will be exercised at the time of payment for the coal, before the 10th of the following month. For example, if a fuel is represented at 50,000 Btu for one cent and the test shows the sample to contain 45,000 Btu for one cent, the amount credited for the 10 ton load shall be five-fiftieths of the price specified in the contract.

Very truly yours,
The De Luxe Coal Co.
By ....
Its ....

ACCEPTED:
The Star Management Co.
By ....
Its ....

This contract form for coal purchases provides for guaranteed Btu values and testing, with definite penalties for poor performance. All of the names shown are fictitious

the latter bill has had that effect on the producers. In an apparent effort to cause the fuels to fall into favored brackets from the standpoint of selling price, the quality of the fuels now represented is often found to be substantially less, from the standpoint of Btu content, than that formerly claimed for them.

New Procedure

The procedure of our office, which purchases 7000 tons of coal annually from nine dealers and for twice that number of different plants, is roughly set out below.

We prepared and proposed to put into effect a firm price, guaranteed contract, with penalties for poor performance. When regular fuel proposals had been taken the next summer, accompanied by the proximate analyses, and decision had been reached as to the dealers and the fuels to be used for the approaching season, the information as to quality and price was inserted in the new forms and the dealers were asked to sign them as contract proposals. One dealer fully approved the method and terms of the contract; a few objected to them and wished to "take them under advisement"; and a few flatly refused to contract on any such basis. All, however, eventually agreed to their use and contracts were made upon that basis with the dealers and for the fuels originally decided upon.

The experience in the ensuing year was substantially better than in any recent previous year. There was less trouble with the fuel, the analyses made from the bins compared more favorably with the guaranteed analyses of the dealers, and the percentage of cases where the coal was above the represented value increased sharply. This method of buying coal on the guaranteed basis seems, therefore, to have materially improved the performance of the coal contracts, and has been demonstrated to be an effective way to protect the consumer's interest.

The type of contract now in use by us is reproduced above (company names are fictitious).

We would be willing, for the further protection of the dealer and the purchaser, to include in the contract another provision, which would be:

(11) In the event that, due to circumstances beyond its control, the undersigned De Luxe Coal Co. is unable to deliver the specified coal of the guaranteed quality, then and in that event, he shall be permitted to obtain relief from continued testing expense by (a) reducing the contract price per ton to a lower figure which shall be mutually agreed upon; or (b) to furnish another grade of fuel, equally acceptable to the purchaser, which will provide the guaranteed value of 50,000 Btu for one cent.

[*Comments on the use of this method and its advantages will be given in a second article.*]

INDUSTRIAL PLANT AIR CONDITIONING

How Operation and Maintenance Are Organized at Air Conditioned Plant

OPERATION and maintenance of the air conditioning systems serving America's large plants which are engaged 24 hours a day in production of war materials for victory must be carefully worked out to assure continuous, reliable and efficient functioning. The organization and procedure successfully used at one such manufacturing plant is described here. . . . There are two classes of operators, one responsible for the equipment involved in supplying chilled or heated water to the air conditioning apparatus, and the other charged with responsibility for the air handling equipment situated in the penthouses. . . . The effort has been made to reduce "paper work" to the minimum, but at the same time to keep sufficient records for assuring efficient operation. A card index file is kept on all maintenance schedules requiring regular attention. Complete checks of equipment are made twice each shift in order to locate and correct any trouble before it assumes serious proportions. Index files are kept of all parts stock, and when an item is taken from stock, a replacement is re-ordered immediately. . . . Regular routines for safety and also for fire prevention have been established

SINCE industrial air conditioning has expanded to the point of totally air conditioned manufacturing plants; problems of operation and maintenance have arisen or have been greatly magnified.

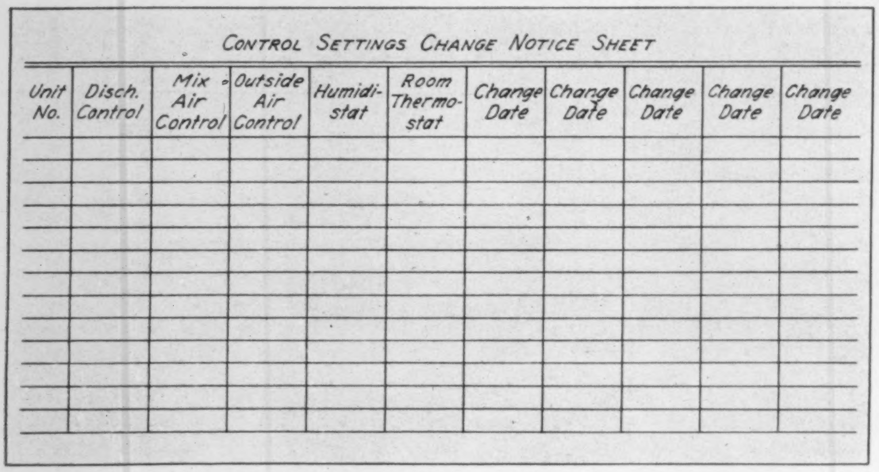
Consideration of these new problems is still a phase of the engineering design of the air conditioning installation. To air condition economically an entire manufacturing plant, the equipment must be laid out with future operation and maintenance aids in mind. For example, the equipment must be sized sufficiently large to handle any normal machinery or manufacturing rearrangement in any section of the plant, with the possible exception of the office sections, in which it would not be practical to increase the capacity to handle manufacturing, since in most cases the office conditioning units differ radically in design from those in the manufacturing sections. At the same time, care must be taken that the air conditioning system is not overly large to the extent that it is difficult to control.

At one of the first of the large, completely conditioned plants for defense work, where 3200 tons of mechanical refrigeration and well water prechilling equipment supply chilled water to 31 separate conditioning systems, it was deemed advisable to provide manual operation of certain phases of the system to give additional flexibility. The operation of all mechanical means for securing refrigerant water temperature is accomplished manually, with the exception of the high and low pressure cutouts on the three 600 hp and the two 300 hp "Freon" compressors, and an outside compensated control for varying the water temperature in winter according to outside temperature. This is done to allow chilled water or heated water to be circulated whenever inside conditions justify it, for use principally during between-season operation. All the air handling units however, have a complete system of automatic controls, pneumatically operated, whose only manual device is a switch for changing the operating sequence from summer to winter, or the reverse, depending upon conditions to be maintained. This method allows a split operation, with certain units operating on the heating cycle, while the more heavily loaded units may avail themselves of outside air as a refrigerant for cooling these areas when the outside air is suitable for such use.

Operation

The operating personnel for the air conditioning equipment at this plant is divided into two classes. First, there are the operators whose duty it is to operate all of the equipment incidental to maintaining proper refrigerant water temperature or heating medium temperature. One man on each of the three 8 hr shifts is assigned this responsibility, which includes the operation of the well water heat exchangers, the steam interchangers, "Freon" compressors, circulating pumps, etc. Second, there are the air handling unit operators, whose work consists of recording the wet and dry bulb temperatures, as shown on instruments placed throughout the building, on logs. Adequate logs are of much value in analyzing the opera-

PRODUCTION
FOR VICTORY



CONTROL SETTINGS CHANGE NOTICE SHEET

Unit No.	Disch. Control	Mix Air Control	Outside Air Control	Humidistat	Room Thermostat	Change Date	Change Date	Change Date	Change Date	Change Date

tion of the entire system for future reference as well as for adjustment of any difficulties of an immediate nature. These logs are taken every two hours by the air handling operator assigned to the particular shift.

Since the plant operates on a 24 hr basis, there is an attendant or operator on hand at all times. All of the logs, charts, etc., are available to each of the operators on the shift as a basis for operating. One of the most vital things to be recorded is that information pertaining to any change, regardless of how minute, in the control settings of the air handling units. For this reason a change notice sheet is filled out by the operator at the end of his shift, on which is indicated any changes made in control settings and why they were made, as well as the date. This information is then recorded in a general log kept at all times to record the work, difficulties and instructions of each shift.

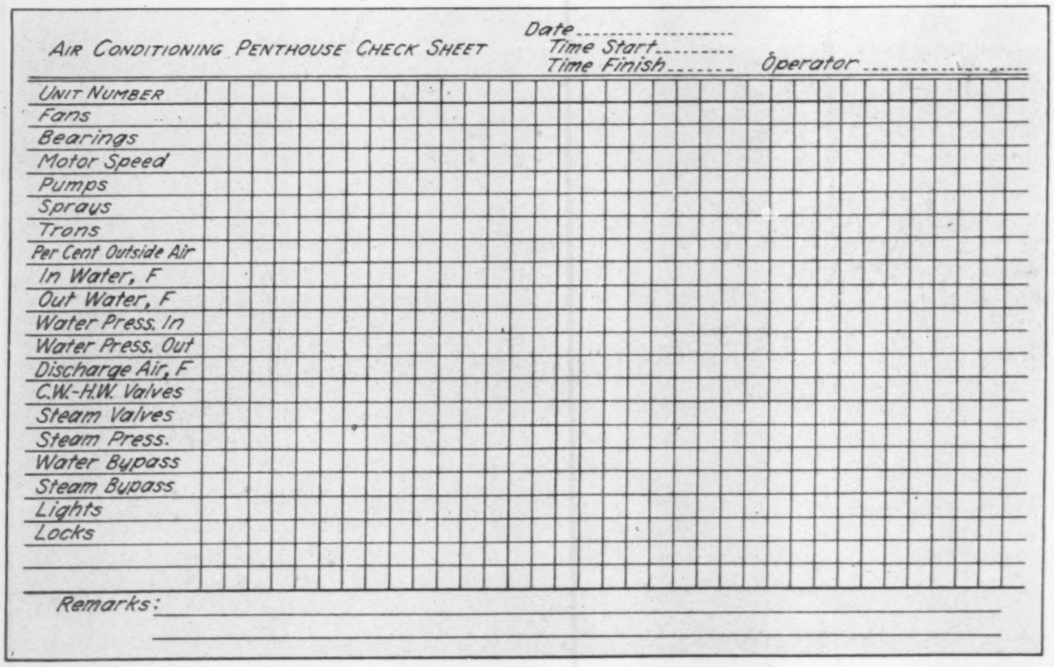
An effort has been made to reduce the "paper work" to a minimum, but adequate records must be kept to give accurate information for securing more efficient operation. Such charts, logs and records are also quite valuable in breaking in new trainees and helpers to the operation routine.

Standardization of the controls for all of the separate systems cannot be complete, except in a general way, since each system has its own peculiarities of operation due to internal load conditions, exposure, peak conditions, etc. It may be said, however, that in the main, each system has the following general controls: A room thermostat which controls the action of the face and bypass dampers and the operation of an automatic water valve controlling the admission of the refrigerant or heating medium to the coils; a discharge control which, in conjunction with the mixed air controls, governs the action of the outside air louvers which are interconnected with the return air dampers to prevent the introduction of too cold air to the spaces conditioned; and a high limit thermostat situated in the outside air stream controlling the action of the outside and return air dampers in summer to prevent the introduction of outside air at a higher temperature than that of the returning air to the cooling coils. Each system also has a set of minimum air dampers that are open at any time the fan is running. In addition, each unit has some refinements of these general controls to combat some local conditioning problems requiring slightly different air temperature or distribution from the main area. This system of control has proved very successful in maintaining the precision manufacturing conditions that the product requires.

In order to aid the operators in securing the proper operation from each one of the sub-controls (as well as from the general system) a framed blueprint of all control piping and control sequence is attached to each unit, as well as complete operating instructions for the unit. With these aids, the operator has only to consult them in order to refresh his mind as to what controls he should adjust to obtain any condition for which the manufacturing space calls. Much valuable time is saved in this manner, since it is exceedingly difficult to carry the sequence of all unit controls in one's mind.

Safety

Safety is a subject given much consideration at this plant, with the result that there has never been a lost time accident or other accident of a serious nature involving the air

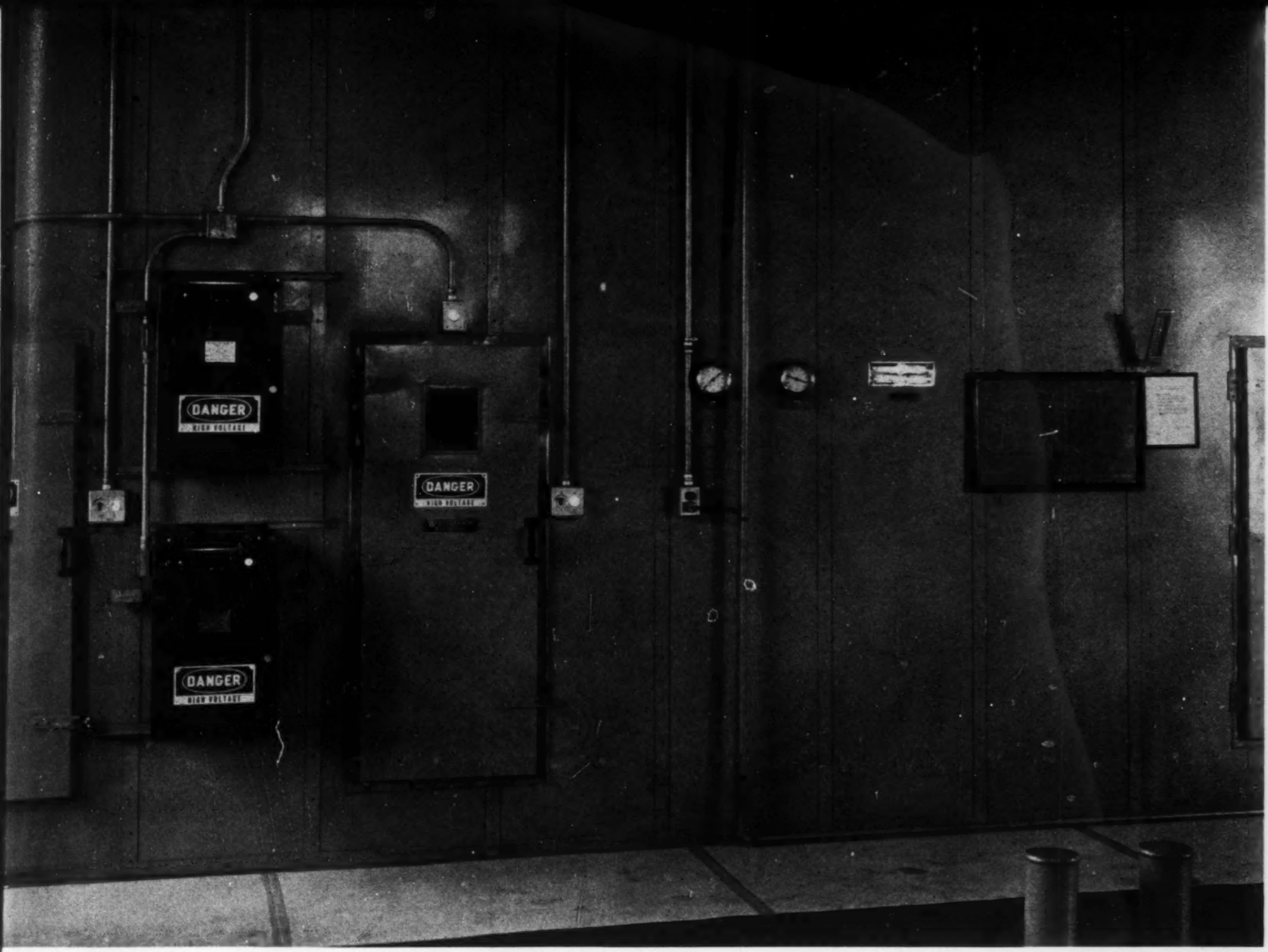


AIR CONDITIONING PENTHOUSE CHECK SHEET

Date..................
Time Start.........
Time Finish.......
Operator..................

Unit Number	
Fans	
Bearings	
Motor Speed	
Pumps	
Sprays	
Trons	
Per Cent Outside Air	
In Water, F	
Out Water, F	
Water Press. In	
Water Press. Out	
Discharge Air, F	
C.W.-H.W. Valves	
Steam Valves	
Steam Press.	
Water Bypass	
Steam Bypass	
Lights	
Locks	

Remarks:



A framed blueprint of all control piping and control sequence is attached to each unit

conditioning equipment in the two years that the plant has been operating, despite the fact that the operators are constantly handling large horsepower motors, high speed drives, electric filters whose plate voltages are approximately 13,000 volts, and like equipment. The systems themselves are designed with all possible thought to safety and operating convenience in mind.

Safety switches are installed on all doors leading to the high voltage filter sections and all equipment of a dangerous nature is plainly marked and protected. Motors, drives and sheaves are protected with safety netting guards. Operating instructions for all electrical equipment are framed and posted near the units. Heavy gage safety netting is installed over all return air openings in the floors of the penthouses containing the conditioning equipment, and all other openings in the units where injury to the operators might occur. Various means, such as safety bulletins and reminders, are brought to the attention of the operators in order that they will not relax their vigilance when operating dangerous equipment. Injuries of any sort have been negligible.

Maintenance

Proper physical maintenance of air conditioning equipment is highly important and too much thought cannot be given to the subject in order to devise faster and more efficient ways of doing this work.

At the plant under consideration, a card file index is kept on all maintenance schedules requiring regular attention, such as motor and fan bearing lubrication, and particularly filter cleaning, since the nature of the manufacturing processes demands that the air supplied to the plant be properly cleaned and filtered at all times to assure the accuracy of delicate gages and machining operations. To this end, the cleaning and maintenance schedule for air conditioning filters requires that they be removed for cleaning, or in the case of electric filters, that they be cleaned at the point of installation, before the filters reach their full dirt carrying capacity. Three men are employed to do this and other maintenance of a physical nature on the air conditioning equipment, which includes the cleaning and maintenance of 15 banks of electrical precipitator type filters and 1200 capillary spun glass filters, 19 penthouses and incidental ventilating blowers and equipment.

Provision is made in each penthouse for hot and cold water for

The Priorities Picture . . .

All chlorine produced in the United States will be subject to direct allocation after February 1, 1942, in accordance with the terms of an amendment to general preference order M-19 issued December 20 by the director of priorities of OPM. War demands for chlorinated products have accentuated the shortage of chlorine which was the occasion for placing chlorine under full priorities control on July 28, 1941.

Suspension orders were issued December 20 by the OPM priorities division against a plumbing supply house for violation of priority orders and regulations. According to the OPM, this supply house ordered 4740 ft of brass pipe and 720 ft of copper tubing with a false statement that the order was entitled to a preference rating of A-10 because the material was to be used as emergency inventory for three hospitals. Inquiry revealed that the supply house had no such orders from the hospitals named. All priority assistance has been withdrawn from the firm until March 1, 1942, by suspension order No. S-2.

Solid Fuels—Secretary of the Interior Harold L. Ickes recommended December 11 that all agencies of the United States government which use solid fuels plan their fuel purchases to provide a comparatively large supply for storage purposes in view of wartime conditions. Simultaneously, he requested information on the solid fuel requirements for the government during 1941 and 1942.

Chromium—Two orders sharply limiting the use of chromium and chrome steel were announced November 27 by the director of priorities of OPM. The first, M-18-a, places in the hands of the director of priorities direction of all deliveries of chromium. The second, an amendment to M-21-a, prohibits the manufacture and delivery of alloy iron or steel containing 4 per cent or more chromium except on A-10 or higher preference ratings. Effect of the two orders will be to retain for defense manufacture all the high chromium content alloy steel produced after December 1, 1941, and to earmark for defense the nation's stock of chromium.

cleaning electric filters, but since the capillary type filters are removable, they are transported to a central room where suitable vats and tanks containing cleaning solutions are available. The cleaning medium employed is a compound of sodium hydroxide and sodium phosphate in solution with water. High pressure steam is used as a final blow-off.

Several spare sets of cells are kept in stock to install in the units when the dirty cells are removed for cleaning, so that no unit operates without adequate filtering at any time.

Where necessary, the electric filters are charged with a light viscosity oil-spray to aid in impinging the dirt particles. This spray is applied by means of a small compressor and a paint spray gun of the pressure type, which is portable and may be easily carried from one unit to another by one man. Extra convenience outlets are installed in each penthouse to provide power for spray gun compressors, electric drills, etc. Only filters in the office sections are usually given this oil treatment, since the manufacturing units usually pick up from the return air stream a sufficient quantity of cutting oil, surface oil, etc., to keep the filter cells well oiled.

All air conditioning equipment and the penthouse interiors are well painted. The floors of the penthouses and units are painted a brick red color, while the unit casings and equipment are painted gray of a shade selected to require a minimum amount of upkeep. Both as a maintenance feature and an operating aid, all piping is painted aluminum and lettered to designate the fluids carried.

Repair Parts

Preventive maintenance is also given extensive consideration. The plant operates 24 hours a day, seven days a week, and 30 days a month—hence any shutdown of equipment is highly undesirable. As mentioned, complete checks of all equipment are made twice each shift in an effort to locate and correct any trouble before it assumes serious proportions. A complete stock of replacement parts for all air conditioning equipment is carried, so that when a replacement part is needed for an emergency repair on the equipment, the item is taken out of stock.

In these days of difficulty in securing parts and equipment for emergency repairs, the replacement parts stock assumes greater importance in keeping the equipment running on a continuous schedule. Index files are kept of all parts stock, and any item taken from stock for a repair is immediately re-ordered from the supplier.

A large belt board designed to take as much strain as possible from suspended belts holds all ropes and drives for the blowers, pumps, etc., and the belts are properly tagged so that no difficulty is experienced when a particular drive or rope is needed for replacement.

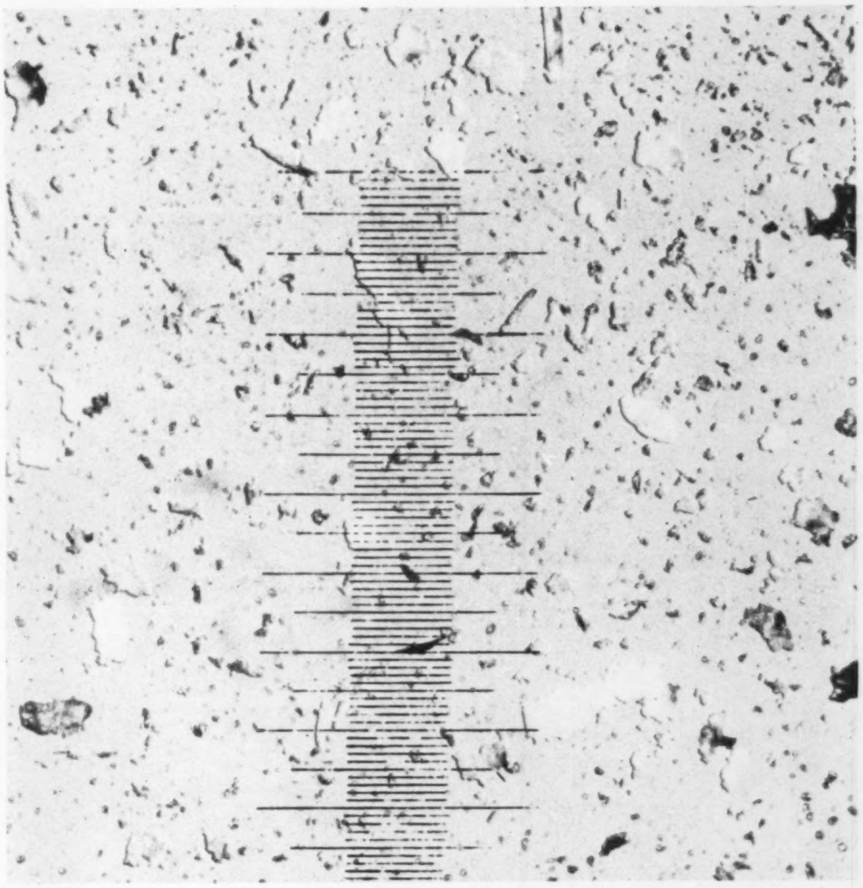
Fire Routine

Another item of interest is the fire routine which the operators follow in the event of an emergency. Due to the fact that extensive manufacturing operations involve milling, burring and grinding of magnesium parts, occasionally small magnesium fires are started from machining sparks or other sources. These small fires are of no particular importance, except to create a very dense white smoke that is soon carried from the discharge air stream from air conditioning ducts from one part of the building to another very rapidly.

When such a condition exists, an operator is immediately dispatched to all affected air conditioning units to manipulate certain controls designed to provide instantly 100 per cent outside air to the units regardless of what conditions the temperature controls are calling for. While this opening of the outside air louvers somewhat upsets the space temperature at times, the time involved in clearing the building completely of smoke is something around 10 minutes and the space temperature is quickly brought back under control.

In the event of a fire of large proportions, however, controls are also available to cut off all outside air manually when the fans are stopped, which would be done in the case of a serious fire in order to avoid additional draft.

DUST CONCENTRATION—In the series of four articles, of which this is the conclusion, equations have been derived by means of which it is possible to predict dust concentrations in enclosed spaces both before and after equilibrium conditions have been reached and when either continuous or intermittent filtering processes are involved. Examples have been worked out illustrative of the methods to be employed in the analysis of both continuous and intermittent filtering systems. . . . The equations derived have been placed on a particle per cubic foot basis but can be translated quite readily to a weight per cubic foot basis and probably to a "soiling power" per cubic foot basis. The possibilities of analysis by these methods are quite varied as application can be made not only to dust and pollen in residential and commercial systems designed for comfort and health air conditioning, but also to some extent in industrial dust control problems. These same equations in modified form can also be applied to various other types of air quality control problems involving concentrations of foreign gases or particulate matter. Thus, it is possible to apply this same theory to the analysis of carbon dioxide concentrations, bacteria counts and other similar problems. . . . The preceding articles appeared in HPAC in December, 1940, February, 1941, and May, 1941. . . . The authors are, respectively, director and assistant professor at the engineering experiment station of the University of Minnesota. Professor Rowley is also a member of HPAC's board of consulting and contributing editors.



Air borne dust particles magnified 1000 times

Predicting DUST CONCENTRATION

Frank B. Rowley and Richard C. Jordan Explain the Practical Applications of Their New Method

IN previous issues of HPAC [December, 1940, February and May, 1941], equations were derived by which it is possible to predict the dust concentrations in enclosed spaces when continuous or intermittent filtering of the air is employed. It is the purpose this month to give examples of the application of these equations to practical problems.

It should be realized that there are two methods of analysis which can be followed: (1) the actual quantitative prediction of the dust concentration in a structure can be made; and (2), the relative efficacy of various factors in reducing the dust concentrations can be predicted. Thus, in the latter case, studies can be made to determine the effect of varying the rate of filtering or of varying the proportion of outside to recirculated air. In those cases where there is insufficient information to evaluate all of the factors which affect the final dust concentration, this latter method of analysis must be employed.

Factory Dust Control

For example, in a factory where it is difficult to determine the actual number of dust particles per minute being discharged to room air by certain machines, it is still possible to study the effectiveness of the dust control system by making reasonable assumptions as to this factor. In this way relative results are determined. The following example indicates one method by which application of this theory can be made to industrial dust problems.

Example 1—A foundry has inside dimensions of 100 ft x 50 ft x 15 ft. An exhaust system with a capacity of 1250 cfm is used for ventilation. When the exhaust system is not operating, the infiltration for a 10 mph wind, as calculated from the crackage, is 325 cfm. Dust count studies made on the interior and exterior air show the inside air concentration to be 15,000,000 particles per cu ft under normal operating conditions with the exhaust system in operation when the outside air concentration is 300,000 particles per cu ft. It is required to determine the following: (a) The rate at which dust is supplied to the air by interior dust sources. (b) The capacity of an exhaust system necessary to reduce the interior dust concentration to 6,000,000 particles per cu ft. (c) The interior dust concentration when the exhaust system is not operating and the only source of ventilation is the air entering and leaving by infiltration.

Solution—

a) In the solution of this problem it is first necessary to assume some typical size-frequency distribution for the air borne foundry dust, since this has not been found directly by experiment. Such a size distribution has been determined by J. J. Bloomfield [Size Frequency of Industrial Dusts, U. S. Public Health Report No. 48, p. 964, August, 1933] from dust samples taken from foundry air. Table 1 shows a summary of these data together with the settling velocities as calculated by Stoke's law and Cunningham's correction factor. Spherical particles and a specific gravity of 2.0 have been assumed. If this distribution is used for purposes of the present problem, the theoretical velocity of fall calculated by means of equation 2 on p. 702 of the December, 1940, HPAC becomes 0.0248 fpm. If a correction factor of 0.5 is applied to this velocity to correct for turbulence and irregular particle shape [see February, 1941 HPAC, p. 101] the actual velocity of fall, v, is then 0.0124 fpm.

The rate of dust production by internal sources may now be calculated by equation 7, p. 100, February, 1941, HPAC. This equation is

$$C_t = \frac{LC_o + D + FC_o\,(1-E)}{M + NE + Av}$$

In this example C_t = 15,000,000 particles per cu ft, $E = 0$ per cent (no filtration of air), $N = 0$ (no recirculated air), $v = 0.0124$ fpm, $A = 5000$ sq ft, $C_o = 300{,}000$ particles per cu ft, $F = 0$, $L = M = 1250$ cfm (infiltration and exfiltration equivalent to exhaust air). Then

$$D = C_t\,(M + Av) - LC_o$$

$$= 15{,}000{,}000\ (1250 + 5000 \times 0.0124) - 1250 \times 300{,}000$$

$$= 19{,}305{,}000{,}000 \text{ particles per min.}$$

b) In this case $C_t = 6{,}000{,}000$ particles per cu ft, $C_o = 300{,}000$ particles per cu ft, $D = 193 \times 10^8$ particles per min, $Av = 62$ cfm, $F = 0$, $N = 0$ and $E = 0$. Substituting these values in the equation for C_t given above and solving for the rate of exhaust air,

$$M = \frac{D - C_t\,Av}{C_t - C_o}$$

$$= \frac{193 \times 10^8 - 62 \times 6 \times 10^6}{6 \times 10^6 - 3 \times 10^5}$$

$$= 3320 \text{ cfm}$$

c) In this case all values are the same as for part (a) with the exceptions that $L = M = 325$ cfm, $D = 193 \times 10^8$ particles per min and C_t is unknown. Substituting these values in the above equation for C_t and solving for the interior equilibrium dust concentration,

$$C_t = \frac{LC_o + D}{M + Av}$$

$$= \frac{325 \times 3 \times 10^5 + 193 \times 10^8}{325 + 62}$$

$$= 50{,}000{,}000 \text{ particles per cu ft.}$$

Table 1—Frequency Distribution and Calculated Settling Velocities for Air Borne Foundry Dusts. (Data from U. S. Public Health Report No. 48, p. 964, August, 1933)

DIAMETER IN MICRONS	AVERAGE FREQUENCY IN PER CENT	SETTLING VELOCITY, FPM, PARTICLE OF MEAN DIAMETER
2.99—2.50	1	0.0948
2.49—2.00	8	0.0644
1.99—1.50	17	0.0396
1.49—1.00	48	0.0209
0.99—0.50	26	0.0081
0.49—0.00	0	0.0012

Contaminants

In addition to problems involving the analysis of dust concentrations in enclosed spaces, these same equations can be used to determine the concentrations of any gaseous or particulate contaminants. The following two examples are given as illustrations of the varied uses to which this type of analysis may be put.

Example 2—A lecture room seating 100 persons is equipped with a ventilation system capable of supplying 10 cfm of outside air per person. When the system is in operation a positive pressure is built up in the room, thus preventing infiltration. When the system is not operating, the rate of infiltration corresponding to a 10 mph wind is 150 cfm. It is required to determine the following: (a) The carbon dioxide concentration in the room with the ventilation system in operation and with a capacity audience. (b) The carbon dioxide concentration in the room with a capacity audience and infiltration as the only source of ventilation.

Solution—

a) The volume of CO_2 exhaled per person is approximately 0.5 to 0.6 cfh and may be taken as 0.55 cfh. The concentration of CO_2 in outside air may be taken as 3 parts in 10,000. If we consider C now to represent concentration of CO_2 in air instead of atmospheric dust concentration, D, the rate at which CO_2 is introduced into the air, and simplify the equation for C_t given above by eliminating those terms equal to zero.

$$C_t = \frac{D + FC_o}{M}$$

The term $C_o = 0.0003$ cu ft CO_2 per cu ft of air, $F = M = 10 \times 100 = 1000$ cfm, and $D = (0.55 \times 100 \div 60) = 0.92$ cfm of CO_2. Substituting these values in the above equation and solving,

$$C_t = \frac{0.92 + 1000 \times 0.0003}{1000}$$

Symbols

A = floor area of enclosed space, sq ft;
C_a = average dust concentration, particles per cu ft;
C_t = inside air dust concentration, particles per cu ft;
C_o = outside air dust concentration, particles per cu ft;
D = dust produced from inside sources, particles per min;
E = filtering efficiency, per cent;
F = outside air, cfm;
L = infiltration air when blower operating, cfm;
M = exfiltration air when blower operating, cfm;
N = recirculated air, cfm;
t_1 = length of "on" period of operation, minutes;
t_2 = length of "off" period of operation, minutes;
V = net volume of room, cu ft;
v = effective settling velocity of dust, fpm.

$$= 12.2 \text{ parts } CO_2 \text{ per } 10{,}000 \text{ volumes of air.}$$

b) In this case all terms are the same as in part (a) with the exception that $F = M = 150$ cfm. Solution with this reduced rate results in $C_t = 65$ parts CO_2 per 10,000 volumes of air.

This concentration of 0.65 per cent CO_2 is slightly below that under which physiological ill effects would be experienced but probably would be accompanied by unpleasant odors. It is considerably higher than good ventilation standards would permit.

Bacteria

Example 3 — An auditorium with a seating capacity of 1200 persons is supplied with 11,250 cfm outside air and 22,950 cfm recirculated air. Air cleaning is accomplished by means of air washers which under actual test show a reduction in bacteria count of 72 per cent without the addition of any germicide to the spray water and 85 per cent when the water is treated with benzylphenol. Tests are made on the completed installation with a capacity audience in the structure and with no germicide in the spray water. It is found that there are 830 organisms per 100 cu ft of recirculated air entering the washer and 178 organisms per 100 cu ft of outside air.

It is required to determine the following: (a) The number of bacteria per minute supplied to the room air by the audience. (This will not include those bacteria directly interchanged between adjacent individuals.) (b) The bacterial concentration in the auditorium air when the washer spray water is treated with benzylphenol. (c) The bacterial concentration in the auditorium air if all air in the supply ducts is treated by means of ultraviolet ray lamps capable of reducing the bacterial content of the air 100 per cent.

Solution—

a) In the solution of this problem the same equations previously derived can be adapted by redefining C as the concentration of bacteria per cu ft of air and D as the number of organisms per minute supplied by interior sources. Then, with reference to our complete equation for C_t given above, $C_t = 8.30$ bacteria per cu ft, $C_o = 1.78$ bacteria per cu ft, $E = 72$ per cent, $M = 11{,}250$ cfm, $F = 11{,}250$ cfm, $L = 0$ (a positive pressure is maintained inside the structure by the introduction of outside air), and $N = 22{,}950$ cfm. The velocity of settling is assumed to be negligible. The equation for C_t may be solved for D and these values substituted. Hence,

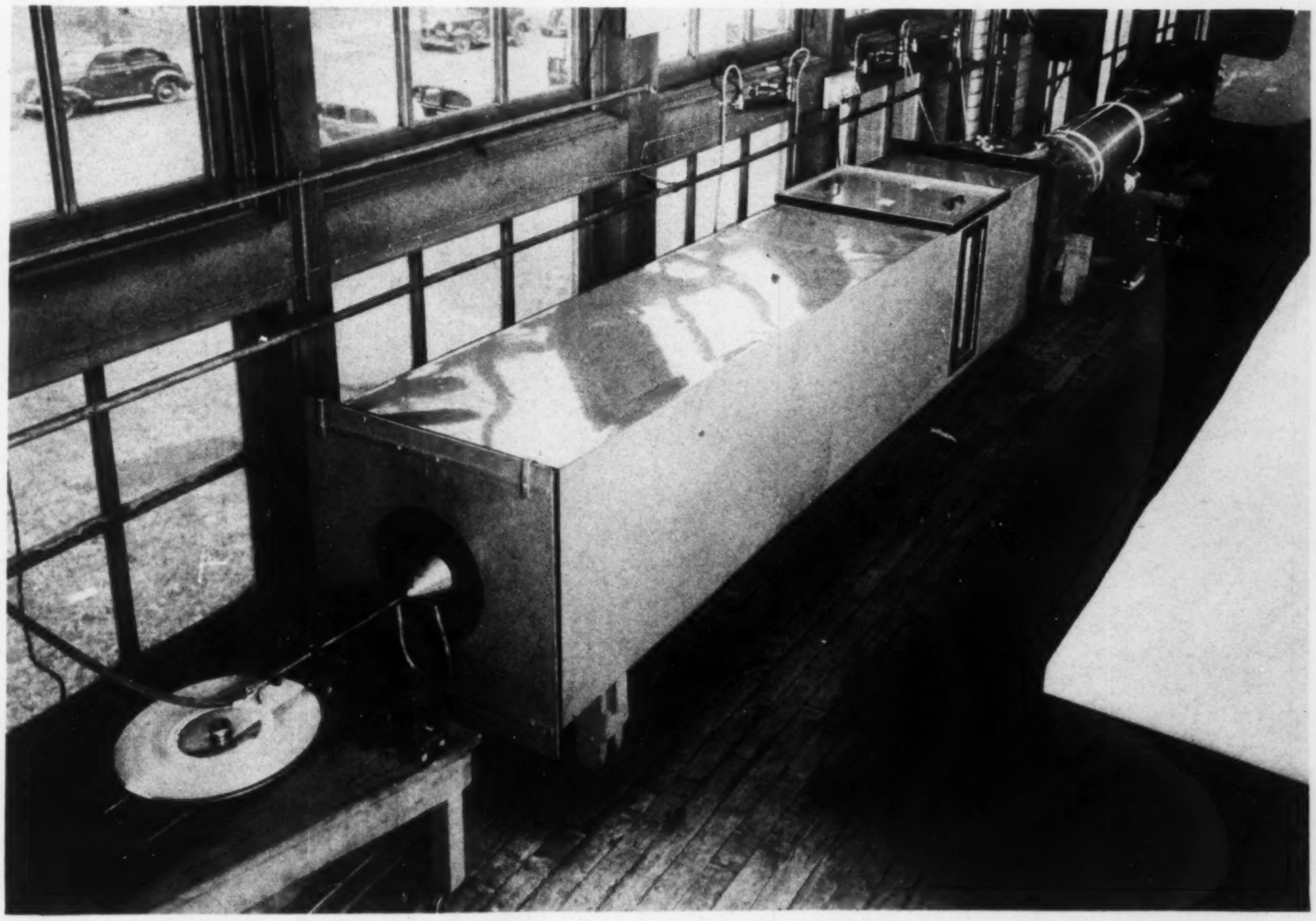
$$D = C_t\,(M + NE) - FC_o\,(1 - E)$$

$$= 8.3\ (11{,}250 + 22{,}950 \times 0.72) - 11{,}250 \times 1.78\ (1 - 0.72)$$

$$= 225{,}000 \text{ bacteria per minute.}$$

b) The rate, D, with which bacteria are being supplied to the interior of the auditorium is now known and the desired value is the concentration of bacteria in the air. All quantities are the same as for

Test apparatus for determining air filter efficiency on weight basis



part (a) with the exception that $E = 0.85$. Hence,

$$C_t = \frac{D + FC_o\,(1-E)}{M + NE}$$

$$= \frac{225{,}000 + 11{,}250 \times 1.78\,(1-0.85)}{11{,}250 + 22{,}950 \times 0.85}$$

= 7.2 bacteria per cu ft.

c) In this case $E = 1.0$ and all other quantities remain the same. Hence,

$$C_t = \frac{225{,}000}{11{,}250 + 22{,}950}$$

= 6.6 bacteria per cu ft.

It is interesting to note the small reduction in bacterial content of air in this problem (8.3 to 6.6 bacteria per cu ft) when the efficiency of bacteria elimination is increased from 72 per cent to 100 per cent. If the problem is carried a step further and bacterial content calculated for the condition of 0 per cent efficiency (neither an air washer nor ultraviolet lamp in operation), the result is found to be 21.8 bacteria per cu ft. This affords an illustration of the diminishing filtration return with increasing efficiency as discussed in our article in the May, 1941, HPAC.

Off and On

Some structures are equipped with mechanical forced air heating systems in which the periods of operation are controlled by the heating requirements of the building, and the air filtration process is incidental. Thus, during the cold winter months when heating requires that the system operate comparatively long periods of time, the ratio of inside to outside dust concentration will be much lower than in the spring and fall months when the intervals of operation are short and the periods between operations are long. The following example affords a good comparison between the dust concentrations in a structure conditioned in this manner and one in which continuous filtration takes place.

Example 4— A small office building 60 ft x 20 ft x 10 ft has a maximum design heat loss of 135,000 Btu per hr and an average heat loss of 77,400 Btu per hr in the month of January and 10,680 Btu per hr in May. Infiltration corresponding to a 10 mph wind is 120 cfm. The air filtration system has an efficiency of 50 per cent based upon dust particle count. The capacity of the blower system is 1800 cfm and the average outside air dust concentration is 500,000 particles per cu ft. Determine the following: (a) The average interior dust concentrations for the months of January and May when intermittent filtering of the air takes place proportional to the heating demands, and there is no provision for outside ventilation air. (b) The average interior dust concentration when the system is designed for continuous filtration with modulation of the heating and there is no provision for outside ventilation air. (c) The average interior dust concentration when the system is designed for continuous filtration with modulated heating and 150 cfm of outside air is introduced.

Solution—

a) This portion of the problem may be solved by the aid of equation 4 derived on p. 305 of the May, 1941, HPAC. It is assumed that there are no internal dust sources ($D = 0$) and that no ventilation air is introduced ($F = 0$). Then $L = L' = M = M'$ and the equation reduces to,

$$C_a = \frac{LC_o}{L + Av + NE\left[\dfrac{t_1}{t_1 + t_2}\right]}$$

For January $\dfrac{t_1}{t_1 + t_2} = \dfrac{77{,}400}{135{,}000}$ $= 0.573$, and for May $\dfrac{t_1}{t_1 + t_2} = \dfrac{10{,}680}{135{,}000} = 0.079$. Also $L = 120$ cfm, $C_o = 500{,}000$ particles per cu ft, $E = 0.50$, $N = 1800$ cfm, and $Av = 60 \times 20 \times 0.003 = 3.6$ (the approximate dust size frequency distribution given in the example on p. 101 of the February article is assumed). Then for the month of January,

$$C_a = \frac{120 \times 500{,}000}{120 + 3.6 + 1800 \times 0.50 \times 0.573}$$

= 93,500 particles per cu ft.

and for the month of May,

$$C_a = \frac{120 \times 500{,}000}{120 + 3.6 + 1800 \times 0.50 \times 0.079}$$

= 309,000 particles per cu ft.

b) If we consider $\dfrac{t_1}{t_1 + t_2} = 1.0$, the equation can be used to solve this portion of the problem with all the remaining values the same as in part (a). Thus,

$$C_a = \frac{120 \times 500{,}000}{120 + 3.6 + 1800 \times 0.50}$$

= 58,600 particles per cu ft.

c) The equation for C_t may be used for the solution to part (c) with $L = 0$, $F = 150$ cfm, $M = 150$ cfm, $N = 1800$ cfm, $E = 0.50$, $D = 0$, $Av = 3.6$, and $C_o = 500{,}000$ particles per cu ft. Then,

$$C_t = \frac{FC_o\,(1-E)}{M + NE + Av}$$

$$= \frac{150 \times 500{,}000 \times 0.50}{150 + 1800 \times 0.50 + 3.6}$$

= 35,600 particles per cu ft.

This concentration is lower than that calculated in part (b) because in this case all outside air is introduced through the ventilation system and filtered, and all infiltration air has been eliminated by building up a positive pressure in the space.

GOVERNMENT NEEDS STEAMFITTERS

The United States Civil Service Commission has announced that plumbers and steamfitters are to be appointed to the government service from civil service employment lists. The positions pay $1680 a year. No written test will be given. Applicants will be rated on the extent and quality of their experience.

A copy of the examination announcement and application forms may be obtained from any first or second class post office or from the commission's central office in Washington. Applications must be on file with the U. S. Civil Service Commission, Washington, D. C., not later than February 5.

"OPEN FOR DISCUSSION"

Communications to the Editor

AIR DISCHARGE FROM NARROW SLOTS

THE EDITOR—

I have enjoyed reading F. F. Stevenson's articles on Air Discharge from Narrow Slots, published in the May and June issues of HPAC, together with the comments of Professors J. R. Fellows and D. W. Nelson appearing in September. My impression of Mr. Stevenson's treatment of the subject is that he approached it from a practical angle with the idea of developing simple formulas or rules—rules-of-thumb, so to speak—that would be valuable to the engineer in the air conditioning field. In so doing some of the scientific formulas may have been slighted, but it appears to me that Mr. Stevenson has specified rather definite limitations for the use of the formulas presented. With particular reference to the formula for throw, it might be a little clearer if it is stated that the throw in feet is equal to

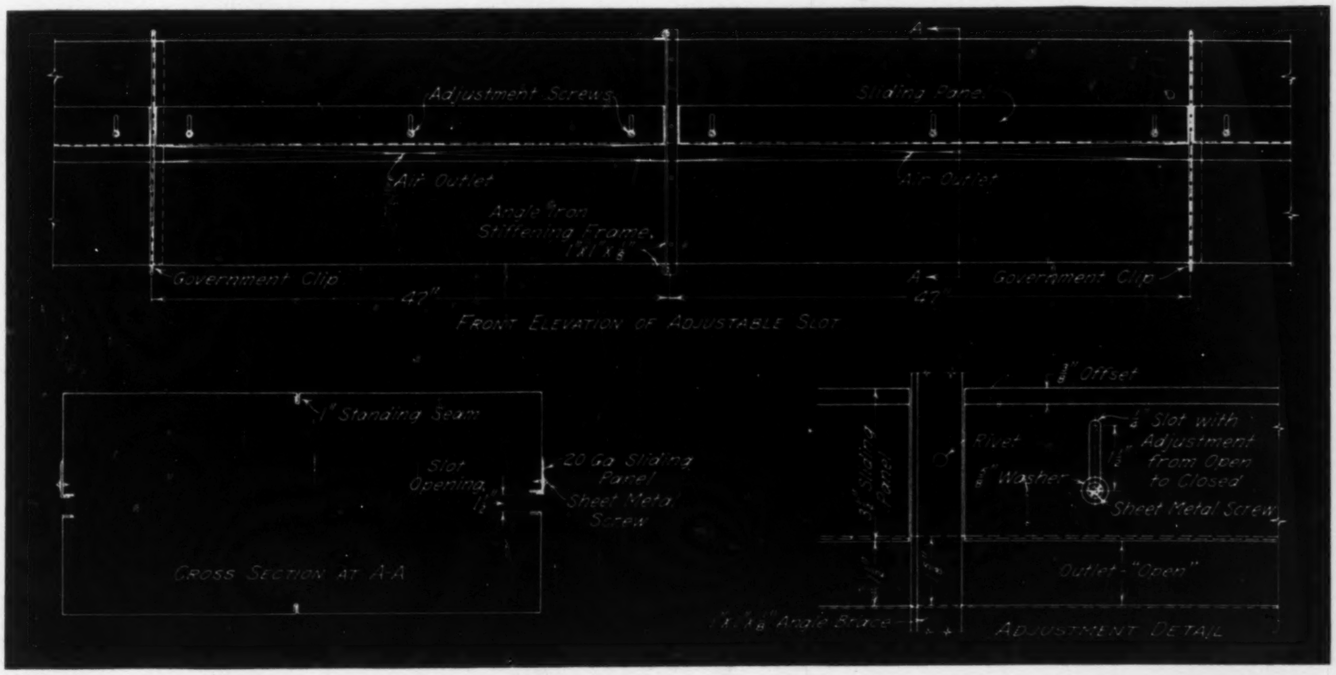
$$\frac{\text{Cfm per Sq Ft of Slot Area}}{48}$$

I believe this formula gives approximate results only and does not give reasonable values if the slot is much more than 3 in. high. Mr. Stevenson pointed out that the constant in the formula varies slightly as between slots 1 to 1½ in. high and slots 2 to 3 in. high.

I beg to disagree somewhat with Professor Nelson regarding the economic aspect of narrow slots versus grilles for industrial air conditioning. A long succession of narrow grilles would be of little value, unless some dampering arrangement were provided; that is, unless each short section of grille were individually designed to suit its particular location along the duct length. Such design would patently be impractical for the ordinary run of job. Furthermore, an adjustable slot can be constructed for as little or less than an open hole with a damper.

Narrow slots for air distribution have been used for many years, and are still extensively used, in orange precooling rooms, grape storage rooms, lemon storage rooms, meat storages and other industrial applications; and for that matter, often in comfort cooling work. In high humidity rooms in industrial work, it is often necessary to add moisture by means of atomizing sprays placed directly in the conditioned room. Here distribution of the air in thin sheets or blankets from narrow slots is of great advantage as the atomizing sprays may be situated above the air blanket and the moisture is distributed uniformly. Thus precipitation on the floor under the spray nozzles is largely avoided. In applications dealing with the storage of foods, cleanliness is a major factor. Open slots are easy to clean.

Various methods are used for adjusting the height of the slot. Often wooden ducts, or ducts made of insulating board, are used and sliding wooden panels or adjustable hinged flappers are provided for adjusting the size of the slot or discharge opening. With sheet metal ducts, the slot can be conveniently adjusted by means of sheet metal slides which may be moved up or down to vary the size of the discharge opening. In industrial work, turning vanes are not extensively used except at


A
Adjustment Screws
Sliding Panel
Air Outlet
Air Outlet
Angle Iron Stiffening Frame, 1"x1"x⅛"
Government Clip
Government Clip
A
47"
47"
FRONT ELEVATION OF ADJUSTABLE SLOT
1" Standing Seam
Slot Opening 1½"
20 Ga Sliding Panel
Sheet Metal Screw
CROSS SECTION AT A-A
⅜" Offset
Rivet
⅜" Washer
¼" Slot with Adjustment from Open to Closed
1½"
Sheet Metal Screw
3½" Sliding Panel
1½"
1½"
Outlet-"Open"
1"x1"x⅛" Angle Brace
ADJUSTMENT DETAIL

elbows in the ducts. The added expense of turning vanes behind a long, narrow slot is seldom justifiable, since adjustment of the height of the slot itself will ordinarily give satisfactory air distribution.

I believe Mr. Stevenson has made a valuable contribution to the engineering information on the subject of air distribution from narrow slots. Further investigation of this subject by the research facilities of the American Society of Heating and Ventilating Engineers should be a worthwhile project.—H. M. HENDRICKSON, assistant chief engineer, Los Angeles office of York Ice Machinery Corp.

CAN CEILING OUTLETS KAYO CEILING SMUDGE?

THE EDITOR—

I have read with much interest Mr. Espenschied's comments (on pp. 752-753 of the December HPAC) on the ceiling smudge article which Mr. Wills and I wrote for your November issue.

In the main, I do not feel that Mr. Espenschied's conclusions differ materially from ours. We stated, "The supply air, that which passes through the duct, is *mainly* guilty" and again, ". . . . . *comparatively* clean ceilings may be had if these precautions are taken."

Mr. Espenschied stated that only *some* of the outlets showed dirt patterns. It is obvious that conditions surrounding the dirty outlets were unusually severe—much more severe than would be encountered on the average job.

It would therefore seem reasonable to assume that under normal conditions a good filter properly installed would give excellent results, certainly much better than would be the case if the supply air were not properly filtered. We still firmly believe that in by far the greater percentage of cases, comparatively clean ceilings may be had if the precautions we recommended in our November article are followed.—G. F. NIGHTINGALE.

PROTECTING TANKS AND SPRINKLING SYSTEMS

THE EDITOR—

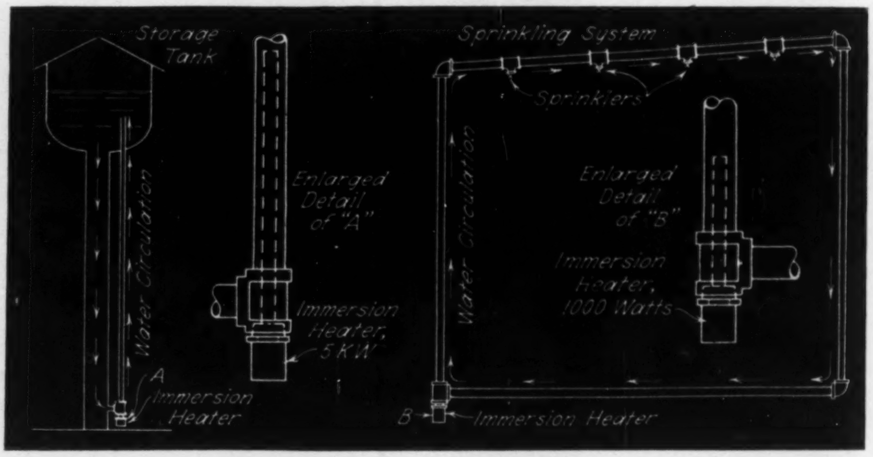
Referring to the article in the November HPAC, on electric heating of piping and tanks, we have engineered numerous installations to prevent damage because of freezing.

Water towers of either steel or wood construction, standing 20 ft or higher above the ground, are troubled during cold months with the water freezing in the large diameter pipe running down from the bottom of the storage tank to the ground. Even insulating this pipe will not prevent the water freezing, and in some cases even the surface of the water in the storage tank may also freeze. As a matter of fact, the installations we have made have all been to prevent freezing of the water surface in the storage tanks.

This has been accomplished by running a 2 in. pipe up vertically alongside of the main pipe, connecting the 2 in. pipe into the main pipe near the ground, and extending the 2 in. pipe up into the storage tank to a point slightly below the minimum point to which the surface of the water may drop in the storage tank. A 5 kw immersion heater is inserted into the 2 in. pipe near the ground end, and the sensitive bulb of a thermostat is placed in the storage tank, slightly below and near the outlet end, at the top of the 2 in. pipe. The result is that warm water, heated by the electrical heater at the bottom of the 2 in. pipe, rises through the 2 in. pipe and discharges in the storage tank near the water surface, making it impossible for the surface of the water to freeze completely across inside the tank and, accordingly, avoiding any possibility of a condition arising where it was required to draw off a large volume of water from the storage tank, which would be impossible if the water surface were frozen solid, since there could be no equalization of air pressure underneath the surface of the ice.

Such installations are economical, since they operate only when the water temperature drops to the freezing point and insure complete protection of water storage tanks that are used as fire protection.

Another application is in factory buildings that are unheated and at the same time are provided with a sprinkling system for fire protection. In such cases, the piping of the sprinkling system is provided with a return line instead of being a dead-end sprinkling system, and at suitable points a 1000 watt immersion heater is installed to maintain the temperature of the water above the freezing point. Some means is provided to assure circulation of the water in the sprinkling system, either by natural convection or by means of a circulator. Automatic control consists of a suitable thermostat set so its contacts will close when the temperature in the room drops below the freezing point. That turns on the immersion heater, so that the complete system is kept from freezing.—M. M. GREER, manager of industrial sales, Edwin L. Wiegand Co.



CHEMICAL CONDITIONING SYSTEM FOR INDEPENDENT HUMIDITY CONTROL

E. A. Windham Describes System Serving Administration and Factory Offices of an Important New Defense Plant

PRODUCTION FOR VICTORY

WELL water for cooling during summer months, conventional heating for the winter season, and independent control of the humidity factor by a chemical conditioning system feature the air conditioning at one of America's new and important defense plants.

The chemical air conditioning system consists of four units. One is situated in the basement of the administration building and provides 20,000 cfm of air. The other three units are in the two penthouses over the factory offices and furnish 25,000, 20,000 and 15,000 cfm of air, respectively. Outside air comprises 30 per cent of the total air circulated in each case, except for the 15,000 cfm unit which supplies 100 per cent outside air for the cafeteria. All the units are similar in principle and purpose of operation.

CHEMICAL conditioning puts the relative humidity under independent control, unaffected by the dry bulb temperature. In the installation described here, a "ceiling" of 40 per cent relative humidity in the conditioned spaces is established under maximum load conditions; under loads below the maximum, the relative humidity in the conditioned spaces is below the 40 per cent value. The author is New York district sales manager for Surface Combustion Corp.

The chemical control equipment comprises contactor cells which provide a chemical solution "wash" for the incoming outside air; a regenerator for reconcentrating and recirculating the solution, and a solution heater and a solution cooler.

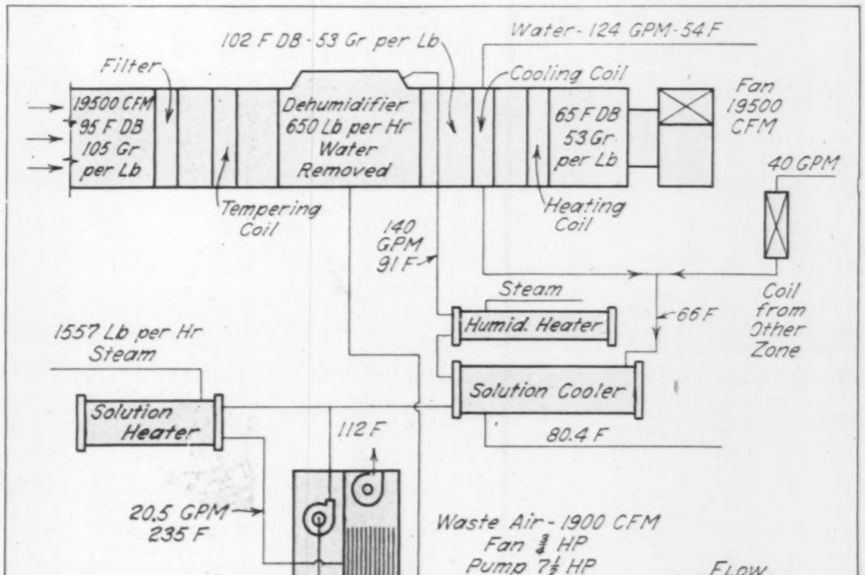
The outside air first comes in contact with the filters and tempering coil, and then is drawn through the contactor cells where it is humidity conditioned. The outside air fan then discharges this air into the main return air plenum. The main air supply returns from the spaces, and is mixed with the humidified or dehumidified outside air. This air is then filtered, and heated or cooled (depending upon the season of the year). The main supply fan then delivers the air through the ducts to the spaces to be conditioned.

Control

Thermostats provide control of the temperature. Each of the buildings is long and narrow with a large percentage of window area. The long sides of the buildings face the southwest and northeast, and there is a substantial fluctuation in the cooling load as the sun shifts during the day. In order to handle this shifting sun load effectively, the buildings are divided into four zones with a thermostat situated in each of the zones to control the air volume for each of these spaces.

The thermostat control during summer operation is accomplished by maintaining a fixed discharge temperature at the main supply fan. A thermostat in each of the fan discharges modulates the 54 F well water to the cooling coil in order to maintain a fixed temperature in the supply ducts.

During winter operation the air conditioning system is used primarily to provide humidification and ventilation. The actual heat loss is taken care of by window radiators. As the main supply fan is equipped


102 F DB - 53 Gr per Lb
Water - 124 GPM - 54 F
Filter
Cooling Coil
19500 CFM 95 F DB 105 Gr per Lb
Dehumidifier 650 Lb per Hr Water Removed
65 F DB 53 Gr per Lb
Fan 19500 CFM
40 GPM
Tempering Coil
Heating Coil
140 GPM 91 F
Steam
Humid. Heater
66 F
Coil from Other Zone
1557 Lb per Hr Steam
Solution Cooler
Solution Heater
112 F
80.4 F
20.5 GPM 235 F
Waste Air - 1900 CFM
Fan ¾ HP
Pump 7½ HP
Regenerator

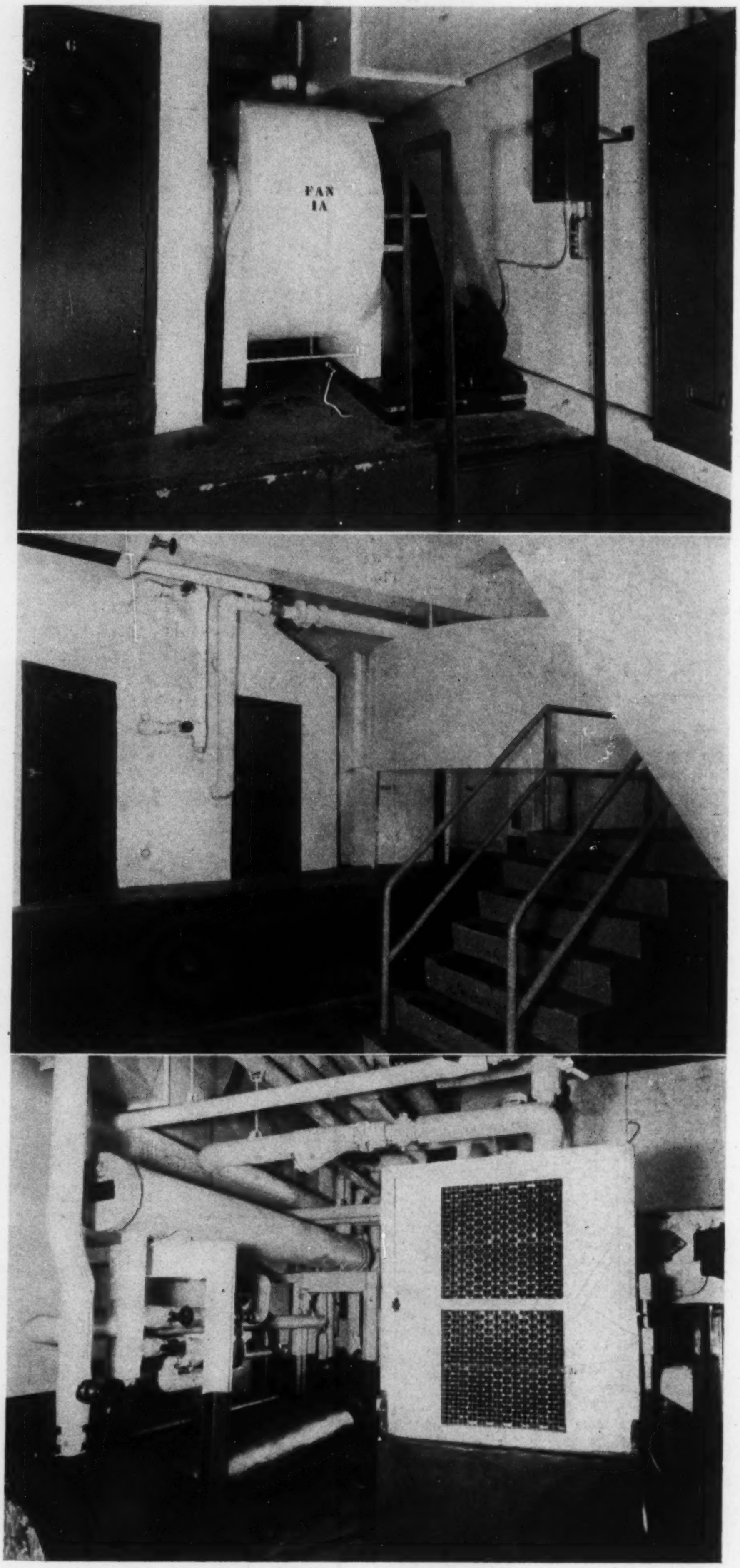
FLOW DIAGRAM

with two speed motors, the fan is operated at half speed in winter, and the temperature at the fan discharge is fixed at approximately room temperature.

Relative Humidity

It is generally conceded that man is susceptible to changes in temperature, but he is not quick to sense changes in relative humidity. This has lead to the assumption, by many observers, that relative humidity is not as important in comfort air conditioning as is dry bulb temperature. Numerous installations of chemical humidity control systems have proved, however, that somewhat higher dry bulb temperatures at lower relative humidities do provide desired comfort conditions.

While the outstanding purpose of the system described above is to control humidity accurately by simply controlling the solution temperature, as used in industrial processing applications, it is considered that a constant solution temperature control is more advantageous in comfort conditioning. Some engineers feel that a 30 to 40 per cent relative humidity is the optimum. In this particular application, conditions were set at 82 F dry bulb and 40 per cent relative humidity maximum. A constant solution temperature in effect places a ceiling on the relative humidity within the conditioned space, under maximum load conditions. In this instance there is no actual humidity control, insofar as attempting to maintain a definite relative humidity. Under any other load conditions (below maximum) the relative humidity is lower than designed. This is the opposite effect than that obtained by mechanical refrigeration methods; in such cases there is a low limit on relative humidity and they often are designed



Top—View of chemical dehumidification air conditioning equipment at industrial plant, showing outside air supply fan which draws air through the contactor cells which are situated within the room indicated by door 6, and discharges it into the main return air plenum. . . . _Center_ — Main return air plenum, indicated by doors 2 and 3, where outside supply air is mixed with return air and is heated or cooled and discharged into duct system for delivery to spaces to be conditioned. . . . _Bottom_—Regenerator in the basement of the administration building. The solution heater and solution cooler are along the wall at left

so that under less than design load conditions, the relative humidity is higher.

The actual results obtained by the system in this plant during the first year of operation have been most satisfactory. Operating charts substantiate this fact by making comparison of actual inside and outside weather conditions for summer months. There was a variance of both temperature and humidity conditions, as previously explained, due to control of maximum conditions only. However, these variations never fluctuated greatly from the set conditions, and were always within the comfort limits.

Costs

This complete installation represented a first cost of approximately 2 per cent greater than the low bid by other methods. At the same time it was estimated that the use of this type of equipment and 54 F well water would effect an operating saving of approximately $1200 per year. The electric power requirements needed for the system are only about 8 hp. The equipment has operated continuously since installation. No service calls have been necessary since each of the units was properly balanced for air volume, and maintenance has been a negligible factor.

Due to constant healthful atmospheres within these offices, it is expected that lost time due to illness will be minimized. Workers have been enthusiastic in their comments about the comfortable working conditions. Also, visitors have remarked of the unusual atmosphere that is being provided by the installation.

This plant was designed by Albert Kahn Associated Architects and Engineers, Inc.

REMEMBER PEARL HARBOR!

The Priorities Picture

The production requirements plan, a streamlined scheme for granting priority assistance to manufacturers engaged in essential production, was issued December 3 by the OPM division of priorities. The procedure is designed to help many thousands of manufacturers of products needed for defense or essential civilian use to obtain priority ratings which will cover their materials requirements for three months at a time. A manufacturer who applies for priority assistance under the production requirements plan will show the type and volume of products he has been making, their use in relation to defense or essential civilian needs, the amount of scarce materials he has on hand, and the additional amounts he will require to fill his production schedule for the next calendar quarter. In determining what priority may be granted to the applicant, the priorities division will take into account (1) the amount of defense or essential civilian production involved, (2) the end use of the products, (3) the materials required for production, (4) the overall policies of the Supply Priorities and Allocations Board, and (5) the recommendations of the appropriate industrial branches of the Office of Production Management. The production requirements plan replaces the old defense supplies rating plan.

Supply houses furnishing materials and equipment to the petroleum industry are assigned a preference rating of A-8 on their orders of specified quantities of materials by preference rating order No. P-83 issued December 8 by the priorities division of OPM. All communications referring to this order should be addressed to the Petroleum Coordinator, Washington, D. C.

Public utilities are forbidden to undertake any substantial expansion of property or equipment without express permission from the Office of Production Management by amendments to preference rating order P-46, issued December 11 by the division of priorities. The order as amended applies to all producers engaged in supplying electric power, gas, water, public sanitation services, or central steam heating, regardless of whether or not they have applied for priority assistance by executing an acceptance of the order. It applies to publicly owned as well as private utility companies, and will cover Rural Electrification Administration cooperatives. The amendments are in line with the policy adopted last month by the Supply Priorities and Allocations Board of disapproving projects for new or expanded utilities unless they are essential. However, projects already under way and at least 40 per cent complete as of December 5 may be finished if the utility has supplies on hand for the purpose, or is granted priority assistance to obtain them.

Defense housing—The priorities division of OPM announced December 11 that 5270 preference rating orders, covering delivery of materials for the construction of 77,871 defense housing dwelling units, were issued in the nine week period from the announcement of the defense housing plan on September 22, 1941, through November 30, 1941. A total of 6943 applications for preference ratings under the plan were received during the period. Of these, 745 were disapproved, and 395 withdrawn by the applicants, or returned to them for correction. The structures covered by the priority ratings issued under the defense housing plan are scattered in some 290 cities, towns and small communities in which the spreading industrial activities of the nation's war effort have caused overcrowding.

Cooperate—The division of priorities of OPM stated December 12 that the exigencies of war make it more important than ever that American business and industry comply immediately and wholeheartedly with all orders and requests for information issued by the division. The warning resulted from a few isolated refusals to report on inventories, needs and uses of certain critical materials. One firm, which had delayed making a requested report, wired Donald M. Nelson declining to do so, stating that a national emergency was no time to be asking for or filing reports. In his reply, ordering that the report be made immediately, the priorities director said, "Your refusal is unwarranted and has impeded the proper administration of the priorities system."

An inventory and requisitioning section has been set up in the Office of Production Management to provide for prompt acquisition of war materials whenever normal sources of supply are inadequate. Through this section OPM may requisition materials directly or may review and approve requisition orders issued by other government agencies.

Consider Evaporative Cooling for

BLACKOUT PLANTS

By Walter L. Fleisher

EVAPORATIVE COOLING—There are many methods of air conditioning, each with its particular advantages and disadvantages. The choice depends upon engineering analysis and the conditions encountered in each individual case. . . . It is Mr. Fleisher's belief that evaporative cooling has particularly noteworthy advantages for controlling temperatures in blackout plants engaged in production for victory. He cites them in this engineering discussion. With evaporative cooling, moisture evaporated into the supply air reduces the dry bulb temperature of the air but increases its moisture content. . . . The author, a consulting engineer, is president of the American Society of Heating and Ventilating Engineers, president of Air & Refrigeration Corp., and a member of HPAC's board of consulting and contributing editors

NOW that war is here, priorities control the use of basic materials and blackouts of some industrial plants have been ordered, it is even more important to the engineer to see what can be done to produce workable conditions in a closed building.

A number of industrial plants erected for the emergency, wisely anticipating the condition with which we are now confronted, prepared for the event by constructing windowless buildings or buildings in which the windows could readily be blackened. These owners installed air conditioning, including refrigeration, to maintain conditions of from 76 F dry bulb and 46 per cent relative humidity to slightly higher conditions. Some of these plants have grouped systems which supply large areas; others have smaller units which independently control smaller areas and are installed on platforms under the roofs of the main building, thus not requiring outside penthouses.

There are a number of these new plants, each requiring from 2000 to 7000 tons of refrigeration; and the new war department building in Arlington is being designed for 14,000 tons, although this is not an industrial plant. Besides these, very large plants, there are innumerable smaller jobs where isolated portions of the plants have been conditioned for specific purposes. First aid rooms, laboratories, constant temperature rooms, drafting rooms, offices and many of the rooms in which sedentary occupations make conditions seem more uncomfortable have systems requiring from 10 to 750 tons of refrigeration. Some of the powder making and shell loading buildings are also equipped with this type of system.

The total tonnage of refrigeration installed because of the emergency must run to several hundred thousand tons. For each ton of refrigeration installed, about 1 hp of electric current is required to operate the refrigeration machine, and about 3 gpm of water per ton must be pumped for condensing purposes. About 3½ lb of "Freon" per ton of refrigeration is also required. As "Freon" has for its base carbon tetrachloride, it is one of the retricted materials on the OPM list. Water is usually at a premium in all large as well as many small installations, so that cooling towers or evaporative condensers have to be installed, and these run into enormous sizes, as cooling water by means of air means the handling of 200 to 300 cfm of air per ton of refrigeration. One cooling tower, just finished to care for 6000 tons of refrigeration, is approximately 250 ft long by 30 ft wide by 30 ft high—a very fair size building in itself—and requires a large amount of power to operate the circulating fans.

CONSTRUCTION FOR VICTORY

It is my belief that due to scarcities of materials and power that consideration should be given—where the conditions permit — to a satisfactory compromise or practical substitute for the complete air conditioning of factories.

With blackouts, one must of course have ventilation. We cannot shut down our production because of danger from aerial bombardment. We must keep on producing, and we must keep the air inside the plants at such a condition that it will be safe to work, even though the blackouts continue for many hours.

What is a simple and economical method of producing *safe* results? Remember, I say *safe* as distinguished from optimum comfort. The answer is, to my mind, evaporative cooling. It is my purpose in this article to show how we can produce the necessary results with evaporative cooling.

In an ASHVE paper on air conditioning in industry, it was shown that men at light work had no appreciable physiological changes up to 87 deg effective temperature, and that they expressed themselves as comfortable at 80 deg effective temperature and at any relative humidity from 30 to 90 per cent.

If we start with 83.5 deg effective temperature, which is below the danger point, we find that approximately 90 deg dry bulb, 80 deg wet bulb, 76 deg dew point and 65 per cent relative humidity are on this line. This means that if we saturate air at 76 deg wet bulb, obtaining a 76 deg dew point, which can be obtained with a very good saturating washer, we have a 14 deg rise in temperature to work with to maintain these conditions. The internal sensible heat load will often run around 28 Btu per hr per sq ft of floor area.

$$H_s = [60\ Q\ (T_2 - T_1)] \div 55.2$$

where

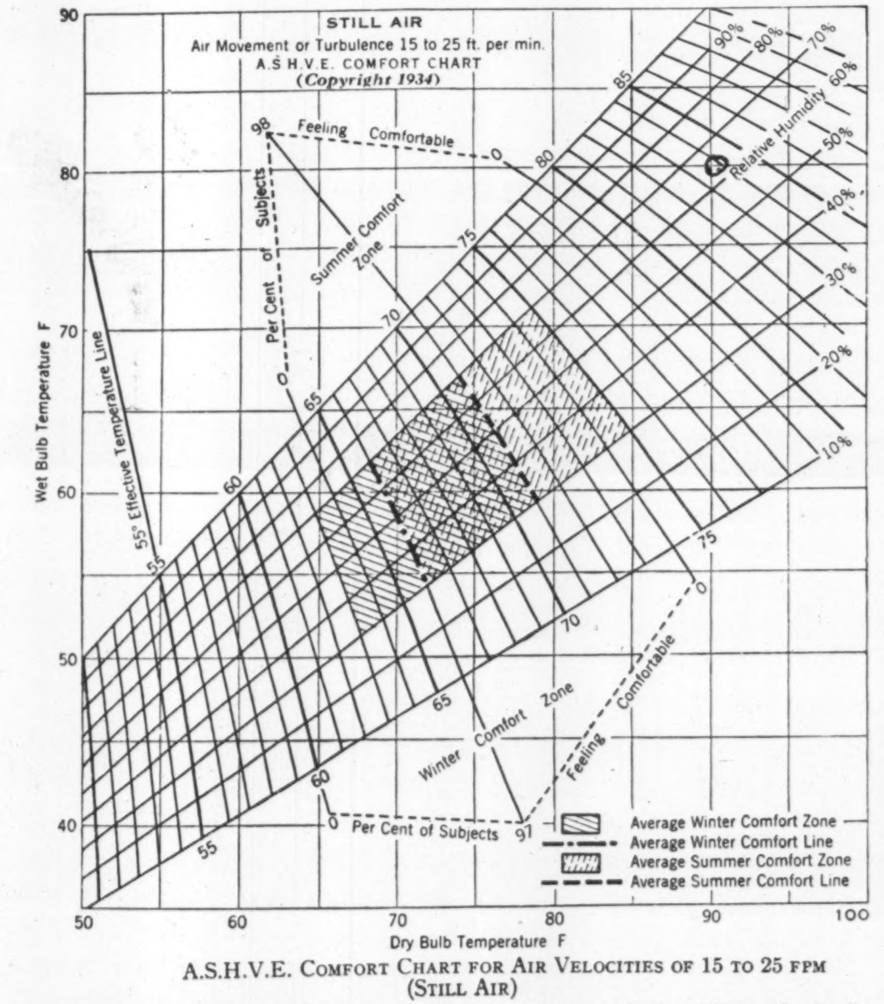
H_s = sensible heat in Btu per hr, Q = air volume in cfm, and $(T_2 - T_1)$ = temperature difference between maintained air and delivery air, F.

Then $Q = (H_s \times 55.2) \div 60\ (T_2 - T_1)$, and if 28 Btu per hr is the sensible heat gain per sq ft of floor area, $Q = (28 \times 55.2) \div (60 \times 14) = 1.84$ cfm, or about 2 cfm of air per sq ft of floor area.

This is scarcely more air than has to be provided with a complete air conditioning system using refrigeration. A's a minimum therefore, at least three-quarters as much air must be furnished with systems using refrigeration as with evaporative cooling systems. The main system of fans, ducts, motors and filters therefore does not change much, and the heating system does not change at all.

Now let us take the other extreme—air introduced for ventilation without either refrigeration or evaporative cooling. If we assume a condition outside of 95 deg dry bulb and 76 deg wet bulb, we start with an 83.5 deg effective temperature; and if the same internal sensible heat is added as in the example above, we would rise to 100 deg dry bulb and 77.5 deg wet bulb, which is an 85.5 deg effective temperature, even though we use three times as much air as would be necessary with evaporative cooling. As all this air would have to come from outside, it would be imperative to filter it.

In conclusion, bear in mind that I am not comparing the comfort of refrigeration in air conditioning with that obtained from evaporative cooling, although much of the time I believe it is equal in comfort. But I say emphatically that evaporative cooling will produce safety and a good deal of satisfaction, and that it fits in with our wartime requirements.



A.S.H.V.E. Comfort Chart for Air Velocities of 15 to 25 fpm (Still Air)

Note.—Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort line is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores, and the like where the exposure is less than 3 hours.

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ANCIENT PIPING SYSTEM ADVANTAGE TO LONDON

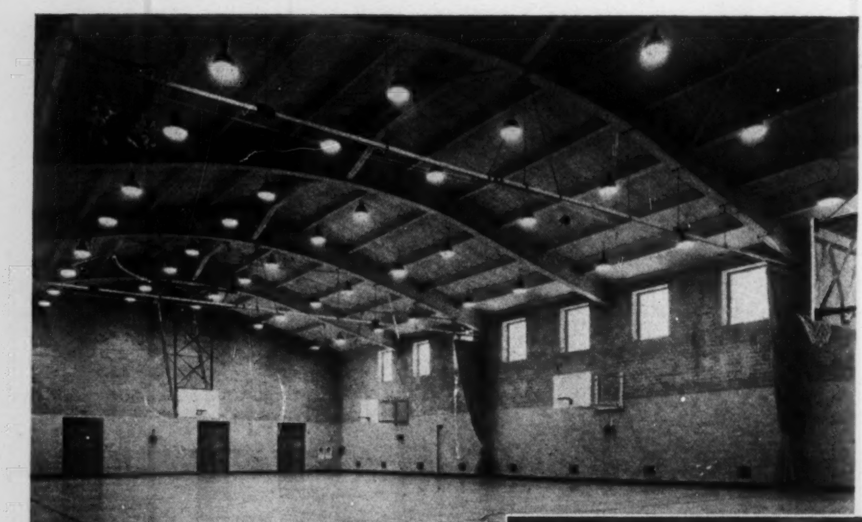
How wartime England has met the engineering problems of power, railways, water supply, buildings and camouflage was described last month at the annual meeting of the American Society of Mechanical Engineers by Walter D. Binger, commissioner of borough works, New York, and chairman of the national technological civil protection committee. Commissioner Binger was sent to England early this fall, and made the trip both ways by bomber over the northern route.

With respect to water supply, Commissioner Binger said that the outstanding feature of England's defense was that every time there had been a bomb crater in the street, permanent repairs were made. He said that he arrived two or three months after the last previous air raid on London and that by then 96 per cent of the breaks in water mains had been permanently repaired and the streets had been repaved.

London was actually saved by its ancient piping system, built over a period of hundreds of years, Commissioner Binger said. This made it possible to reach every district by several different feeders. He said he was advised to bring back to American engineers the message that water supply systems should have the maximum number of cross connections.

Commissioner Binger said he had been inside of large factories in England in which the whole working space was not less than 80 ft underground. These factories were built, he said, in abandoned quarries, with 80 ft of solid rock cover. They were bombproof and required no blackout.

The American Society of Refrigerating Engineers last month presented its distinguished service award to Willam S. Shipley, one of its past presidents, in recognition of his leadership and outstanding effort in developing and bringing into successful use the "York plan," a cooperative plan for coordinating the community's civic and industrial activities in the interest of the national defense program. Mr. Shipley is chairman of the board of York Ice Machinery Corp., chairman of the defense committee of the Manufacturers Association of York and chairman of region 10 of the Pennsylvania division of contract distribution of the Office of Production Management.



Main gymnasium of Northwestern University's Patten gym. This room is heated without any direct radiation. Heated air is forced in at high velocity through nozzles in west wall (not shown), creating a turbulence that uniformly heats and ventilates the room. Exhaust grilles are along lower edge of the east wall at right

Photos by Hedrich-Blessing Studio

Natatorium of Patten gym. Because of 80 F temperature and the excessive humidity common in indoor swimming rooms, no air is recirculated. Warm air enters through ceiling air diffusers and is withdrawn from grilles placed under windows

High Velocity Air Circulation Solves Problem of Heating

LARGE GYM OR ARMORY

Method originally developed for dial telephone exchanges and industrial use answers the requirements of Northwestern University's Patten gym

BY circulating air at high velocities, engineers of Holabird & Root, Chicago architects, have solved the problem of heating and ventilating a large gymnasium or armory floor. First non-industrial application of the method, developed by Norman E. Bueter, Holabird & Root's chief mechanical engineer, is in the new Patten memorial gymnasium of Northwestern University, Evanston, Ill.

No Radiators

In the gymnasium proper direct radiation has been completely eliminated. The room is heated entirely by air that is "squirted" through nozzles at a linear velocity of 2000 fpm. The tapered nozzles, 8 in. in diameter and with a slight upward tilt, are placed 9 ft above the floor along one side of the gymnasium. Exhaust grilles are near the floor at the opposite side. Smoke tests made in the gym reveal that the air injected through the nozzles travels in a sharply-defined horizontal plane to the center of the room and is then diffused throughout the chamber before being exhausted. The turbulence created by these streams assures thorough circulation of heated air throughout the room. Because the inlets are high on the wall, there is virtually no draft on players and spectators at floor level.

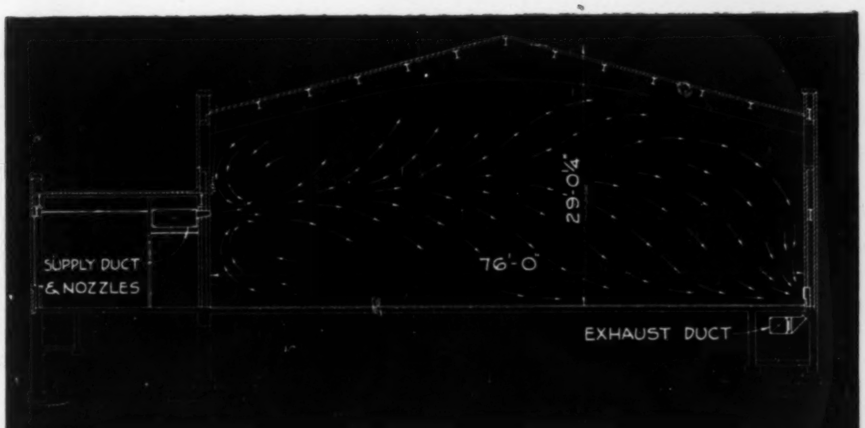
Industrial Scheme

This method of circulation was developed primarily for telephone and industrial uses.

The Illinois Bell Telephone Co. has employed Holabird & Root since 1911 for the design and engineering of plant facilities valued at more than $15,000,000, because the firm includes in one organization unusually large and experienced mechanical, electrical and structural engineering departments.

Advent of dial telephones and automatic exchanges created unusual problems. It was necessary to ventilate low ceilinged switchboard frame rooms up to 80 ft in width without floor and ceiling outlets. Mr. Bueter, who had supervised heating, ventilating and air conditioning installations for motion picture theaters, suggested that the nozzles used under balconies in theater work might solve the telephone company's problem if the pressures and velocities used were stepped up.

The system used in the new dial exchanges worked successfully with velocities of approximately 1700 fpm. When the Patten gym job was undertaken, the higher speeds used in the industrial installations were introduced, and have proved successful in a year of operation. Air leaves the supply system at 1800 fpm, is stepped down to 1000 fpm. in branch ducts, and reaches 2000 fpm in the constriction of the nozzles.



SCHEMATIC DIAGRAM OF VENTILATING SYSTEM
PATTEN GYMNASIUM

The ventilating system is varied slightly in the natatorium, where outside air enters in outlets in the center of the ceiling, and is exhausted near the water level. Because of the room temperature being maintained at 80 F with an unusually high humidity, no air is recirculated.

High velocity circulation is used also in the rifle range, now devoted primarily to naval reserve instruction, where the swiftly moving air carries powder smoke away from the eyes of the cadets on the firing line.

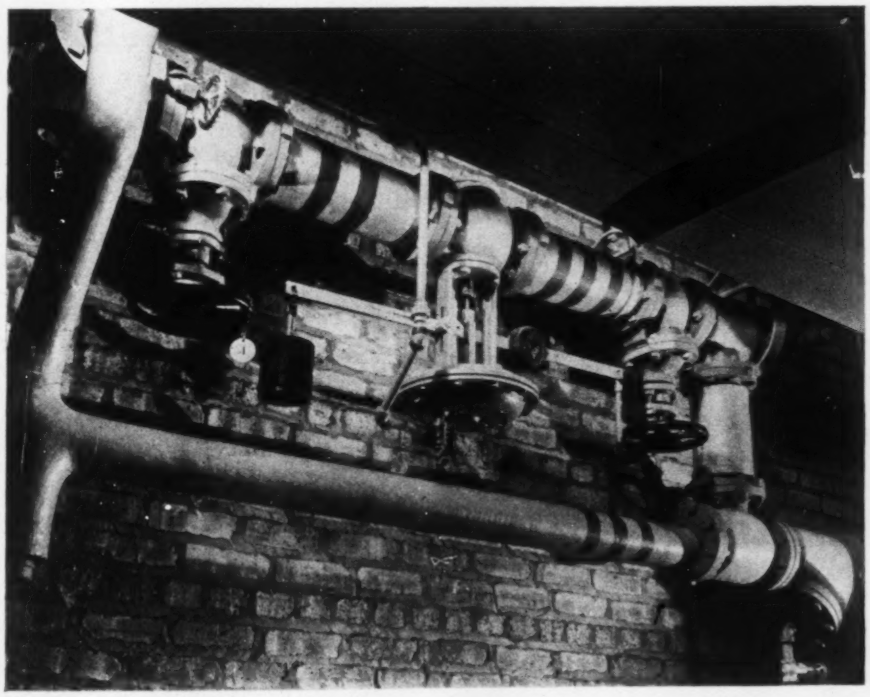
Normal direct radiation, with a vacuum return system, radiators and convectors, is used to heat smaller rooms, offices, hallways and the lobby.

Central Steam Plant

Patten gym, along with all other buildings on the N. U. campus, receives its steam from a central heating plant.

The steam pressure in the supply line is approximately 40 psi, dropping to 5 psi in a pressure reducing station. These valves, and all others in the building, are coded with brass tags, while every pipe line in the building is coded with color bands to guide the maintenance staff.

Reducing station at which steam entering Patten gym from tunnel of university supply system is reduced from 40 psi pressure. Reducing valve, top center, and bypass line below. All valves are tagged. Pipe lines have identifying color bands



CHINS UP! DACHSHUNDS CAN'T LICK BULLDOGS

. . . is the slogan appearing in an advertisement in one of our Canadian contemporaries, and to which we take typewriter in hand to object. Maybe it's none of our business—dogs aren't within our editorial scope (unless they live in air. conditioned kennels), and the writer doesn't own one.

It's unfair and inaccurate, we think, to pin nationalistic labels on man's best friends. A most moving passage—supposedly true—in a best selling novel of a few years back described the fatal stoning of a dachshund by a gang of ruffians old enough to know better but influenced by the careless and cruel thinking which is one of the worst aspects of war.

Let's keep the dogs out of this.

Design of an Oil Fired HIGH PRESSURE STEAM PLANT

By Kalman Steiner

STEAM PLANT—Mr. Steiner (consulting engineer for the Ray Heat & Power Co., and member of HPAC's board of consulting and contributing editors) starts at the beginning in this discussion of designing an oil fired plant for supplying process steam. This month, he considers the choice of fuel, determining the load and the load factor, boiler capacities, boiler types and boiler selection. In a second article, he will cover oil burning, piping, pumping and storage. . . . His articles are based in part on the design used for a number of recent national defense construction projects outside the continental United States

THE greatly accelerated rate at which munitions and armaments will be needed now that war has come upon us will require that we increase what was already a large scale production program under defense planning. Many process steam plants are being designed and erected as rapidly as circumstances permit. All manner and style of materials are needed, requiring in turn that there be a sufficient number of production units. In most production operations, high pressure steam is utilized in some way or other, besides the conventional applications of heating and power. It seems to suit the planning of some government authorities to erect moderate sized steam generating units, in preference to very large ones, as the smaller boiler rooms can be scattered, thereby avoiding concentration of large amounts of equipment and capacity in single locations. This program is so vast that few of us realize the variety and extent of the actual projects involved. But the facts are that the output of our factories making boilers, pumps, heat exchangers and kindred boiler room apparatus is largely being absorbed in wartime construction.

Alternate Fuels

In ordinary times, the choice of fuel would depend chiefly upon economic factors, such as availability, transportation, handling costs, labor rates and (of course) fuel cost. To a large extent, these factors still enter into the selection of fuel for wartime production. But there remains the important consideration of alternation of fuels, or the ability to burn more than one kind of fuel. The exigencies of war may give rise to unexpected interruptions in supply and transportation. Much thought should therefore be devoted to adapting a plant to switching rapidly from one fuel to another. With present day methods, it is neither difficult nor unduly expensive to provide such plants with means for burning any one of the three principal fuels—coal, oil and gas—or even for burning two of them simultaneously.

Aside from the fuel aspect, most moderate sized, high pressure steam generating plants have many similarities, and conventional engineering methods will work out suitable designs. Many of the original design problems will originate in working out the fuel handling equipment. It is the aim of this paper to discuss the principal points involved in the design of such plants when oil fired.

Designing for Oil

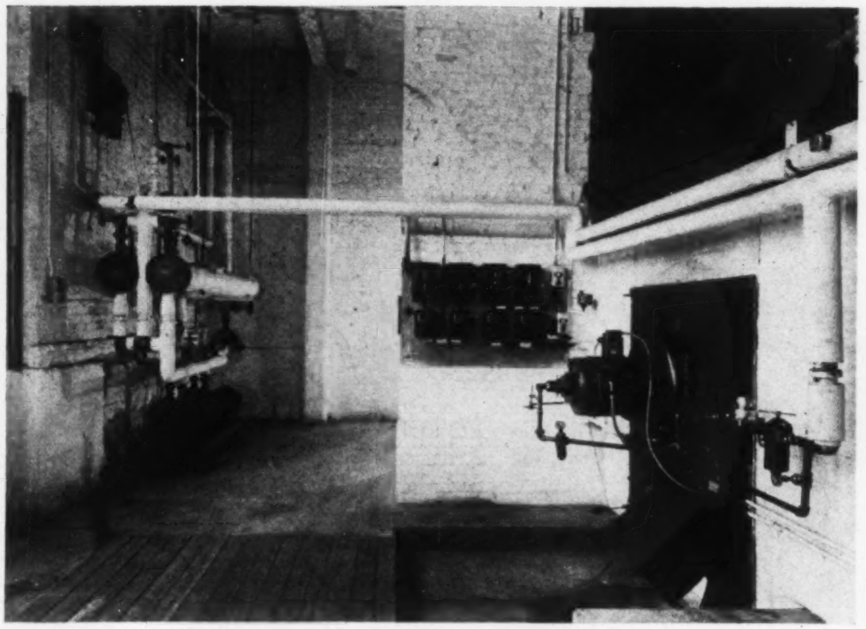
Any oil burner installation, to be satisfactory in performance, should incorporate a certain balance between its component parts that integrates those parts into an assembly so uniform or synchronous that each part really loses its separate identity and merges into the whole. In a high pressure plant especially, it is important that the designer work out correct proportions between the various units entering into it. The load, the boiler style and capacity, the boiler setting, the draft, the burner size and firing range, the control type and application, the oil pumping and piping system—all are interrelated and there is a definite dependence of one upon the other.

CONSTRUCTION
FOR VICTORY

The starting point for design is of course the load. It is not often possible to assign a definite value to it, however. Even assuming that it has been definitely determined just what steam using equipment is to be installed in the plant, it is rarely found that every piece of connected machinery will be in full operation at the same instant. Usually, the operation of machinery is somewhat staggered, some machines going into use as others are taken off the line. The proportion of total machinery in use at any time is the load factor, and it is necessary to determine the value of the load factor at the peak demand. Then, of course, an ample factor of safety is added. Since experience is the best guide, the safest procedure is to consult the plant management as to the probable maximum or peak load factor. Every different type of plant will have peculiarities of its own.

Piping Loss

Piping loss is important in determining load. After the insulating method has been decided and the pipe runs laid out, it is a simple matter to calculate the piping loss The loss should be based on the steady state—that is, of piping up



Close-up of one boiler of a battery, showing circulating oil lines, strainer and oil meter. In the background are the oil pumps, strainers and heaters, and in the center may be seen the electrical switches

to full steam temperature. The pickup period from a cold start will condense steam at a faster rate than the steady state, but in process steam applications the warming up occurs before the equipment is placed in operation, so the steady state is attained before the process load comes on. This is in contrast to heating plants, where the maximum condensing rate is brought about by the combined loads of the cold piping and cold radiation.

The peak load factor and the piping loss added give the boiler load to be carried. Next to be considered is the question of plant expansion. In the average case, this is so uncertain a factor that the safest solution is to provide space for additional boilers, to be added when and if needed. In newly constructed boiler rooms, it should not be too difficult to allow sufficient boiler room space for this purpose. Should this entail too much construction and space expense, then it becomes necessary to include a capacity factor for load extension.

Boiler Capacity

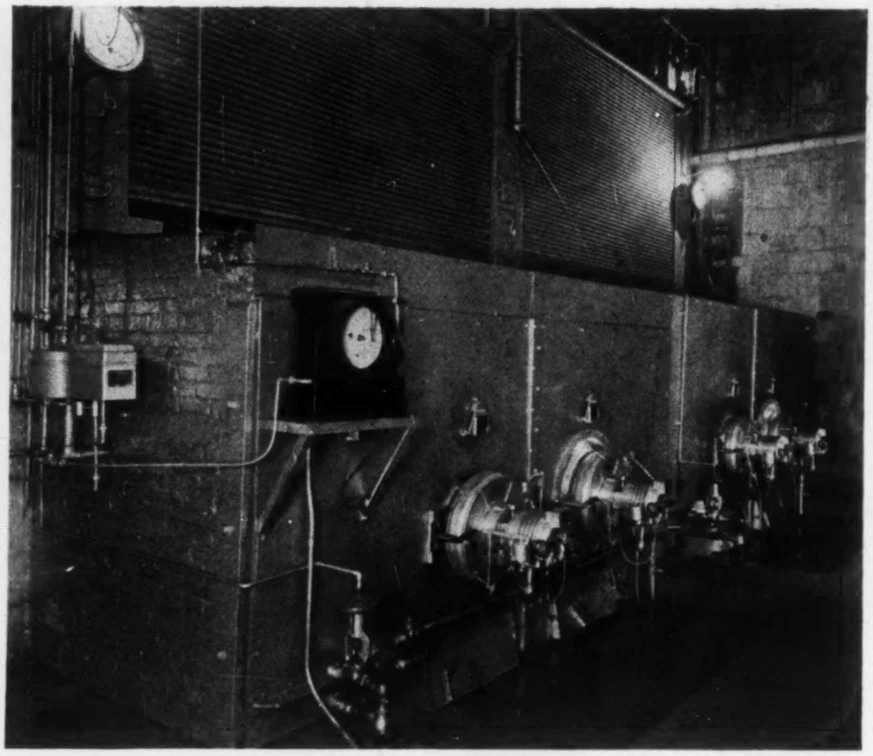
In considering the matter of boiler capacity, a lot of confusion will be avoided if all references to it are reduced to a common denominator. Otherwise, capacity terms are likely to be quite misleading. For instance, manufacturers of fire tube boilers will generally rate their boilers in terms of boiler horsepower, based on 10 sq ft of boiler heating surface constituting one boiler horsepower. Then it will be explained that such boilers are capable of carrying overloads, 150 per cent output being common and 200 per cent not infrequent. Makers of water tube boilers seem inclined to state boiler output capacity in terms of pounds of steam per hour *maximum,* in the case of large units, but still retain the old boiler horsepower designation in the case of small units, using the conventional 10 sq ft to one boiler horsepower. In the latter event, it will then be explained that water tube boilers can develop up to 300 per cent, and even 400 per cent of the horsepower rating. Certain combination boiler-burner units are rated on the basis of 5 sq ft heating surface constituting one boiler horsepower.

Too often, it is overlooked that the steam making capacity of a boiler is largely determined by other factors than the boiler heating surface—furnace volume, draft, refractory type and rate of heat release, and burner firing capacity, to mention but a few. It might be added that rules of the Steel Heating Boiler Institute governing rating procedure are not applicable to high pressure boilers, even though identical construction is followed. [For a more complete discussion of boiler rating, see How Big Is a Boiler?, by Kalman Steiner and Fred Ravnsbeck, HPAC, October, 1940.]

The most suitable unit for expressing boiler capacities and boiler loads would be the Btu, or the Mbh (1000 Btu per hr), but as yet the industry has not adopted this universal procedure. For the present, therefore, the most convenient unit seems to be a thousand pounds of steam. The amount of heat contained in a pound of steam being a function of the feedwater temperature and the boiler nozzle pressure (assuming no superheat, which is generally the case with process steam plants), it is necessary to postulate some conditions for a quantitative discussion. We will here assume a feed temperature of 165 F and a boiler gage pressure of 100 psi. Each pound of steam so generated represents 1055.85 Btu absorbed in the boiler.

For illustrative purposes we will assume that a decision has been made to provide for a maximum steam demand of 45,000 lb per hr. The first question then is the selection of a boiler or boilers. A water tube boiler could be selected to carry this entire load. To permit of shutting down for cleaning and repairs, and yet maintain continuous operation of the plant, at least two such boilers would be needed. Water tube boilers give excellent results with all fuels, provided the setting is suitable. In the case of oil, there should be 1 cu ft of combustion space for each 30,000 Btu per hr released. Higher rates of heat release will jeopardize the refractory walls. Should the boiler be constructed with water tubes against the firebox walls, however, the heat release rate may be one-third greater, or 40,000 Btu per hr per cu ft. These boilers operate at good efficiency through a wide range of output. The specific shape of the firebox, and the firing control, are determined somewhat by the type of burner selected, as will be mentioned later. Water tube boilers are always brick set, making the installation a permanent one. It is for this reason, principally, that the use of these boilers is not extensive in temporary or semi-permanent plants.

Battery of two boilers with two burners each. At left is the hydraulic draft control, and in the center are the CO_2 recorder and the stack temperature recorder



Fire tube boilers are made in three characteristic forms: firebox, Scotch marine and horizontal tubular. The first two are the so-called portable, meaning that they can be dismantled and moved from one location to another without involving any considerable amount of bricking, although the firebox boiler requires somewhat more refractory than the Scotch marine. The horizontal tubular boiler is entirely brick set, like the water tube, and its installation is strictly a permanent one. The combustion chambers of the firebox boiler and horizontal tubular boilers should be designed for a heat release rate not in excess of 30,000 Btu per hr per cu ft, since there is a considerable refractory surface. Scotch marines must have dutch ovens to give increased combustion volume beyond that contained within the internal furnace of the boiler. But since little refractory is used in this boiler, except for the outside extension, a heat release rate of 40,000 may be used. There are three distinct regions to a Scotch boiler fire-

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The Pattern of Life Today —as Seen by One Engineer

By John Howatt

Chief Engineer, Chicago
Board of Education

Member of HPAC's
Board of Consulting
and Contributing Editors

Progress—Today the world witnesses machines developed and improved originally with the thought they would be used in commerce, industry and homes for the advancement of civilization and to improve the living status of man being turned against him to destroy him and his works. Some wonder if the engineer through his scientific research has brought forth a whole family of Frankenstein monsters that will destroy the very race they were designed to serve. The radio has become a device used by the enemy to spread propaganda and misinformation in an endeavor to destroy our spirit and morale. The automobile has become the armoured car and tank spouting fire and destruction in its path. The airplane has become the bomber raining death from the sky. Does this imply that because of such use of appliances, research and invention have failed civilization? That we would be better off if we went back a century before the era of invention to the days of the oxcart and the once-a-month mail delivery?

Certainly not. The answer is not found in stepping backward. Our civilization cannot become either stationary or retrogressive. Life and civilization can survive only when there is motion, when there is growth. We must look toward tomorrow using the experience of yesterday only as a light by which we may guide our feet on the path leading forward. Man was not brought on earth to compete with dumb creatures sentenced for life to hard, onerous tasks. Man has been endowed with the faculty of thought which has given him dominion over all creatures of the earth and it is the development of mind in mankind that has released him from many of the burdens that have bowed the head and stooped the shoulders of so many generations in the past.

Our enforced adoption of devices intended to make life more worth living in order to destroy that we ourselves may survive cannot stop the progress of our civilization in its movement toward a better living. Search for the new and improvement for the old will continue and there are many fertile fields in which research can be carried on. Some of the results that may come from research within the next 10 years will be so revolutionary our whole economic and social program and our outlook may be changed by them. Research in the fields of releasement of stored energies; research in the field of photo-synthesis to arrive at the secret of the action of sunlight in plants, which may lead to the secret of life itself; research in foods; and research into the causes of certain human emotions and reactions, are but a few of the fertile fields that may be named. The engineer, the physicist and the chemist can look into a future that promises to add much to the science of living.

Men and Machines—The past few years of world disturbance have proved the vital importance of machines in determining the destiny of nations and box—the front extension or dutch oven, the internal cylindrical furnace, and the rear combustion chamber.

Draft

Practically any boiler can be operated with either natural draft or mechanical draft. In peacetime practice there is decided advantage to natural draft operation for moderate sized plants, although large plants find it desirable to utilize mechanical draft. For medium sized plants, the investment in an adequate chimney is easily justified, for then there is no power requirement or maintenance of mechanical equipment to provide draft. But for wartime construction, there are two factors favoring mechanical draft: there is a decided saving in time and material by omitting a chimney, and should the plant be discontinued after hostilities cease, the fan can be utilized elsewhere but a chimney cannot. Perhaps a third point might be that in areas subject to aerial attack, a chimney offers a good target.

Boiler Selection

Boiler type, required output, furnace design and draft having been decided upon, boiler manufacturers can be invited to bid on what they deem to be boilers of the required capacity. But to assure that all will bid with caution in regard to developing specified output, a guarantee clause should be included. A fair guarantee requirement would be 77 per cent overall boiler efficiency as determined by an ASME evaporation test, short method. If a plant designer still prefers to pin the manufacturer down to a quantitative statement of heating surface, it should be based on a ratio of not less than 126 sq ft per 1000 lb of steam generated at 100 psi gage from a feed temperature of 165 F. for water tube boilers, and not less than 180 for fire tube boilers. In terms of more conventional expressions, these are equivalent to 250 and 175 per cent of rating, respectively, on the old basis of 10 sq ft heating surface to the boiler horsepower.

It has been mentioned that should the choice of boiler type be for water tubes, there should be two, each capable of carrying the entire load. Fire tube boilers of course are not made in such large sizes. From the above ratio and the stated load to be carried of 45,000 lb per hr of steam, it is evident that a total boiler heating surface of 8100 sq ft must be provided in fire tube boilers. These boilers are made in various stock sizes, such as 1800 2000 and 2500 sq ft each. It is evident that for the plant under discussion, there would be needed five each of the first two sizes, or four of the third. Whichever be selected, an extra one should be added for a spare. A wise choice would seem to be either six 1800 sq ft boilers, or five 2500's.

[*A second article by Mr. Steiner will consider oil burning, piping, pumping and storage.*]

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their peoples. Machines of destruction against which mere flesh, blood and valor have no chance are used in every theater of war and any defense that fails to be built against a machine-dominated offensive is futile. But machines must be directed by men, constructed by men and designed by men; back of every machine must be skilled operators, builders and designers.

We have heard a great deal about bottlenecks in material, but the most serious bottleneck has been in the shortage of skilled artisans and mechanics. The listing of engineers, chemists and other professions in a pool was a move looking toward making the most of our resources. The shortage of skilled mechanics today is an indictment of the short-sighted policy in the curtailment of the apprenticeship system during the lean years. The rush toward vocational training now is but a belated recognition of the need of the times.

The necessity of keeping young engineers and mechanics in industries when they are engaged in war work instead of having them serving in the front line battle forces is well recognized.

Since machines are so important in our war effort, those mechanics who are giving their best efforts on the construction of defense and war plants and in the operation of machines in those plants in producing goods, supplies and equipment called for by our military and naval forces are just as essential as are the men assigned to ships, planes or guns. Every citizen is a soldier and as a soldier must be willing to accept the assignment given him, whether it be in the air, on the sea, in the field or in the shops and factories. In my mind there is no difference in the need, no distinction in the degrees of responsibility, and there will be an equal sharing of the satisfaction and thanksgiving when victory is achieved.

Labor has pledged its full effort on war and defense work to keep production at full speed. This will prove necessary to compete with the man output of those who now oppose us. We are rapidly getting the machines, we are rapidly getting the men. Our Secretary of Agriculture has stated "Food will win the war and write the peace." I believe, that while hunger has always been an important factor in shaping history, that this war must be won by the four M's—Men, Machines, Money, Morale. And what an important part labor is to play in this effort.

We sometimes feel that in periods of national crisis like the present, social services like education are subordinated too much to the production of material things. We know that the maintenance of many social services is essential to the strengthening of morale so needed to withstand the depressing effects of unfavorable reports. It is admittedly true that services like education must be continued to the limit of the resources deemed advisable by those in general command of the nation. However, the objective of all must be to prosecute the war to victory, distributing *all* our resources and energies where they will be most effective. It is no longer one group competing with another, one seeking preference at the possible expense of the other. We now can demonstrate that in crises democracy can mean one for all and all for one.

What a heartening thing it is to consider the son of the banker training and marching alongside the son of the baker. This is democracy in action. Can the engineers and craftsmen in the designing room and factory do less? They too must march side by side to produce the machines and all tools of defense and war so those at battle stations will not be empty handed. When peace is won we can again resume that healthy, competitive spirit of living that has made this the strongest nation in energies and materials that has existed on earth. The engineer, the skilled mechanic, and their machines, will again lead the parade.

Adjustments—Everyone in the United States for the past several months has been affected directly or indirectly by the application of priority ratings on materials and projects. Those who have had to obtain preference rating certificates and make accounting of everything bought and sold, have had the drastic change from free buying and selling impressed on them more forcibly perhaps than have others not engaged in any business—but everyone has been affected. The diversion of the efforts of all industry to matters of national defense placed a severe strain on the goods distribution mechanism as well as bringing about a need for study of the different kinds of materials that could be used in manufacturing. In many instances now it may be necessary for manufacturers to change their lines almost completely or temporarily go out of business. Since necessity is the mother of invention and invention is a byproduct of research, the forced changes in the industrial program of the United States have been a definite stimulation to research to find ways of producing goods of quality out of materials not stipulated to be used exclusively in the national victory program.

The defense and now the war program is changing the life of every individual and the operating methods of nearly every industry in the United States.

Buying and selling practices, too, have been adapted to the times. Just a few years ago reciprocal buying was practiced to the extent that it was feared it would become a factor helping to make the large companies larger and the small companies smaller. The policy of selling where you buy made it difficult for small business concerns to deal with the large concerns except, where they had some patented monopoly. Today, while some companies are reasonably requesting that goods of their own make be used in contracts on their own work, they are not directing that goods not of their own make be purchased from a firm with which they may have business dealings.

The market in many classes of goods has changed in the last year from a buyer's market to a seller's market. For some time it has not been a matter of price, but one of delivery. The sales organizations so essential as the stream bringing life to industry and business have often become staffs of order takers and corps of field diplomats trying to placate the customers because of delays in deliveries. It is gratifying to note that in this time when many buyers are seeking the salesmen rather than the salesmen the buyers, that there seems little indication that sales organizations are permitting the situation to affect their policy in maintaining cordial, friendly relationships with their customers. There seems to be a general understanding that the present type of activity is not representative of our normal state and that when the war is won the making of new friendships and the holding of old ones will be an even more important factor in selling goods.

The general handling of the strange and difficult situations brought about by emergency action and the need for speed speaks well for industry. Profit is not the sole driving force in this day. Patriotic Americans are found in every walk of life in every branch of service. The uncomplaining way in which adjustments to a new way of thinking and doing are being made everywhere speaks well for the strength and capacity of the people of this nation.

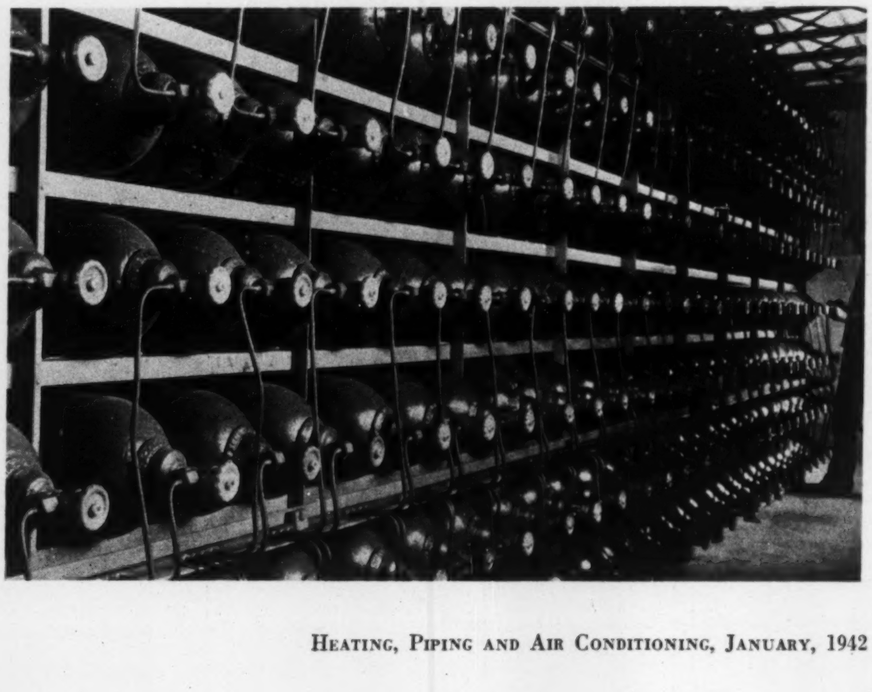
Relax—The engineer is trained to consider efficiency, to weigh the relation between input and output, to compare the energy expended with the results obtained. He knows there are certain elements that when introduced will always lower efficiency of performance. One of these is friction, which sets up a resistance to action. He therefore realizes the importance of lubrication, oil that removes the strain and thereby makes possible better efficiency and better performance. He does not always realize, however, that the same general laws apply to the performance of humans as to machines, and does not treat his mind and body with the same consideration and understanding with which he treats mechanical appliances.

A tension or tightening up of the mind and muscles under the stress of work or circumstance is setting up resistance against the best performance. We must learn to relax, first the mind, then the body, if we will do our work well and expeditiously. Today, with bitter conflict on every hand and with the problems of readjusting finances to meet the increased taxes necessary for winning the war ever before us, it may be difficult to ease the strain. The burden in today's war-torn world is especially difficult, for no one who is alive and takes the part in life he should can close himself in his own private cloister and shut out the discord about him.

Situations must be met. When you feel yourself becoming tense and rigid, pause and do nothing for a few minutes, relax, find something to laugh about if possible. Take time out if need be to count a few of the blessings we citizens of this land still enjoy, perhaps the most precious of which are freedom of thought and freedom of reasonable speech and action. Feel the tension in mind and body melt away; then, when you resume, you will learn that the friction has been reduced, that the human machine appears to have been lubricated so it functions more easily, its output is increased and efficiency improved.

The time for this pause will be time well spent. It will provide the opportunity to strengthen the fortress within the individual to help withstand the stress and strain, the friction and the heat of turbulent affairs. A strong mind in a well body is an efficient combination that is certain of success.

OXYGEN HAZARDS are reduced by housing cylinders in a separate building 350 ft away from the new Westinghouse fluorescent lamp plant, Fairmont, W. Va. The oxygen gas in the cylinders at 2000 psi pressure is connected to a manifold system and reduced to approximately 100 psi. It is then piped underground into the main building and reduced to about 10 psi pressure for use on the lamp machinery which requires oxygen and gas or air. To eliminate corrosion and at the same time reduce the possible hazards in oxygen gas lines, all piping and fittings are made of copper. Special pipe line filters at each machine are used to eliminate foreign material. The oxygen is delivered in liquid form by a truck fitted with devices to convert the liquid into gas and pump it into the cylinders



HEATING, PIPING AND AIR CONDITIONING DATA SHEET

Eliminating the Week-End Blackout of Industrial Plants

IN view of Washington's call for doubled and quadrupled war production by increasing the maximum work week to seven 24 hr days, the Timken Roller Bearing Co.'s "no-blackout" plan is now even more important. Numerous requests for details of the plan have been received.

Steps were taken almost two years ago to inaugurate a system that would enable the company to keep its equipment running 168 hr a week (24 hr a day for seven days) to eliminate "week-end blackouts" while still complying with the 40 hr work week. Keeping step with the expansion of defense and war needs, one department after another has been put on this schedule.

In brief, this "anti-black-out schedule" calls for three 8 hr shifts per day up to 40 hr per week. By having four crews (instead of three) to handle these three shifts, the company is able to rotate the working time for each crew so that it works 40 hr a week (the four crews thus keeping the equipment running 160 hr a week).

By an ingenious scheduling arrangement of shifts and crews, each crew works five extra shifts over each period of 20 weeks (for which overtime is paid). These five extra shifts for each of the four crews are all that is necessary to bring the "equipment work-week" up to the 168 hr total.

This schedule has been so carefully worked out that every man works five days in a row and then is off at least 48 hr, after which he changes shifts. And over each period of 20 weeks, each man has five Sundays off. The shift schedule runs 20 weeks and then repeats without change.

On the next page is reproduced a copy of the schedule chart which shows in detail exactly how the plan works. You will note that the three *shifts* are listed in the left hand column; and that the four crews are designated by the letters *A, B, C* and *D*. If John Doe is a member of crew *A*, the hours designated by the letter *A* on this chart show exactly the hours and shifts he will work during the entire 20 week period.

PRODUCTION
FOR VICTORY

Shift Schedule for 168 Hour Week

	1. WEEK	2. WEEK	3 WEEK	4 WEEK	5. WEEK	6. WEEK	7. WEEK	8. WEEK	9. WEEK	10. WEEK
DATE →	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐
	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT
1st (NIGHT) SHIFT 12 MIDNIGHT TO 8 A.M.	B B C C C C C	D D D D D A A	A A A B B B B	B C C C C C D	D D D D A A A	A A B B B B B	C C C C C D D	D D D A A A A	A B B B B B C	C C C C D D D
2ND (DAY) SHIFT 8 A.M. TO 4 P.M.	A A A A B B B	B B C C C C C	D D D D D A A	A A A B B B B	B C C C C C D	D D D D A A A	A A B B B B B	C C C C C D D	D D D A A A A	A B B B B B C
3RD (AFTERNOON) SHIFT 4 P.M. TO 12 MIDNIGHT	D D D D D A A	A A A B B B B	B C C C C C D	D D D D A A A	A A B B B B B	C C C C C D D	D D D A A A A	A B B B B B C	C C C C D D D	D D A A A A A
DAYS PER WEEK	A B C D 6 5 5 5	A B C D 5 6 5 5	A B C D 5 5 5 6	A B C D 6 5 5 5	A B C D 5 6 5 5	A B C D 5 5 5 6	A B C D 6 5 5 5	A B C D 5 5 6 5	A B C D 5 5 5 6	A B C D 6 5 5 5
DAYS PER PAY PERIOD	A B C D 11 11 10 10		A B C D 11 10 10 11		A B C D 10 11 10 11		A B C D 11 10 11 10		A B C D 11 10 10 11	
SUNDAYS OFF	C	C	C	C	C	B	B	B	B	B

	11. WEEK	12. WEEK	13. WEEK	14. WEEK	15. WEEK	16. WEEK	17. WEEK	18. WEEK	19. WEEK	20. WEEK
DATE →	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐	☐☐☐☐☐☐☐
	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT	SUN MON TUE WED THU FRI SAT
1st (NIGHT) SHIFT 12 MIDNIGHT TO 8 A.M.	D D A A A A A	B B B B B C C	C C C D D D D	D A A A A A B	B B B B C C C	C C D D D D D	A A A A A B B	B B B C C C C	C D D D D D A	A A A A B B B
2ND (DAY) SHIFT 8 A.M. TO 4 P.M.	C C C C D D D	D D A A A A A	B B B B B C C	C C C D D D D	D A A A A A B	B B B B C C C	C C D D D D D	A A A A A B B	B B B C C C C	C D D D D D A
3RD (AFTERNOON) SHIFT 4 P.M. TO 12 MIDNIGHT	B B B B B C C	C C C D D D D	D A A A A A B	B B B B C C C	C C D D D D D	A A A A A B B	B B B C C C C	C D D D D D A	A A A A B B B	B B C C C C C
DAYS PER WEEK	A B C D 5 5 6 5	A B C D 5 5 5 6	A B C D 5 6 5 5	A B C D 5 5 6 5	A B C D 5 5 5 6	A B C D 5 6 5 5	A B C D 5 5 6 5	A B C D 6 5 5 5	A B C D 5 6 5 5	A B C D 5 5 6 5
DAYS PER PAY PERIOD	A B C D 10 10 11 11		A B C D 10 11 11 10		A B C D 10 11 10 11		A B C D 11 10 11 10		A B C D 10 11 11 10	
SUNDAYS OFF	A	A	A	A	A	D	D	D	D	D

CREW A	CREW B	CREW C	CREW D
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
14	14	14	14
15	15	15	15
16	16	16	16
17	17	17	17
18	18	18	18
19	19	19	19
20	20	20	20
21	21	21	21
22	22	22	22
23	23	23	23
24	24	24	24
25	25	25	25

SHIFT SCHEDULE

FIVE CONSECUTIVE WORKING DAYS, FOLLOWED BY AT LEAST 48 HOURS OFF
SHIFT SCHEDULE RUNS 20 WEEKS AND REPEATS WITHOUT CHANGE

CREW A	CREW B	CREW C	CREW D
26	26	26	26
27	27	27	27
28	28	28	28
29	29	29	29
30	30	30	30
31	31	31	31
32	32	32	32
33	33	33	33
34	34	34	34
35	35	35	35
36	36	36	36
37	37	37	37
38	38	38	38
39	39	39	39
40	40	40	40
41	41	41	41
42	42	42	42
43	43	43	43
44	44	44	44

You will note that the three *shifts* are listed in the left hand column; and that the four *crews* are designated by the letters A, B, C and D. If John Doe is a member of Crew A, the hours designated by the letter A on this chart show exactly the hours and shifts he will work during the entire 20-week period.

Every man works five days in a row and then is off at least 48 hours, after which he changes shift.

Over each period of 20 weeks every man works five extra days, totalling 105 shifts in 20 weeks.

Over each period of 20 weeks every man has five Sundays off.

Over each period of 20 weeks every man has five pay days with 10 days pay and five pay days with 11 days pay, if he works full time.

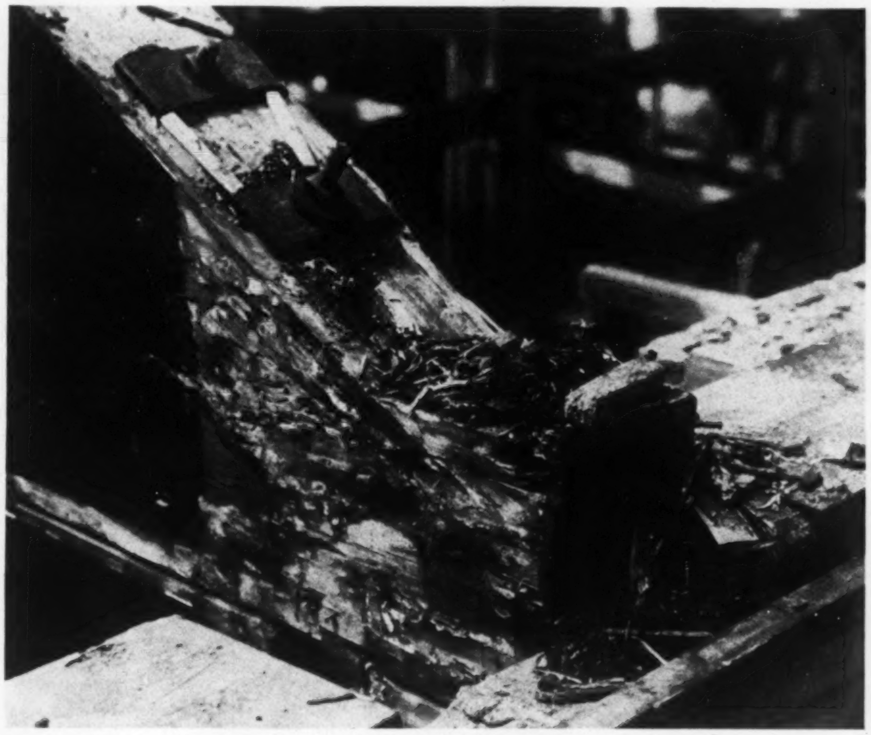
Same crews are always working together.

No relief men are required.

Bad Humidity Conditions Almost BROUGHT DOWN THE ROOF

Improved Heating and Ventilation—with Humidity Control—Halts Deterioration of Roof Structure . . . . By Lester S. Ries

CONSERVATION—Particularly in these days, when materials are difficult to obtain and should be conserved for greater production in our all-out war effort, the maintenance of our buildings is taking on added importance. If this maintenance is not thorough, deterioration will take place and in some cases with a rapidity that will necessitate extensive repairs and replacements. Every effort, therefore, should be made by maintenance organizations to inspect thoroughly buildings under their jurisdiction and make whatever adjustments are necessary . . . An example is typified in the experience at Oberlin College with its Crane swimming pool, as described here by Mr. Ries, superintendent, Oberlin College department of buildings and grounds. High humidities caused rapid deterioration of roof construction; this was corrected by revising the heating, ventilation and adding humidity control



Typical condition of truss at bearing wall. Improved heating and ventilation and humidity control has corrected the cause

IT IS seldom that a fully enclosed, all-weather natatorium is housed in a building that is completely isolated from any other structure. Such a building was erected at Oberlin College in 1930. The swimming facilities consist of two pools—one 75 ft x 35 ft with the water varying in depth from 3 to 8 ft, and the other 15 ft x 35 ft with water about 3 ft deep. The room in which the pools are situated has 13 large outside windows with exposures on the north, south and east elevations. The west side of this room is a solid partition beyond which are the showers, toilets, lockers and other facilities. Above the room is attic space that is 15 ft high at the ridge and tapering to nothing at the eaves on all four elevations.

Originally the roof of the building was supported by timber trusses resting on the exterior walls. The heating for the pool area was accomplished by means of 13 recessed radiators and two basement-situated blower heaters, one at the north and one at the south end of the room. These unit heaters were operated with a thermostat situated in the pool area, took outside air only, and furnished the heated air into ducts at the four corners of the natatorium space. The room temperature of the pool is carried at 85 F, and the moisture content of the air is at saturation.

The heated air introduced into the room then forced an equivalent amount of exhaust through registers into the attic space, and from the attic space the air flowed to the outside through roof ventilators. In other words, the attic was used as a plenum chamber.

Timbers Rotted

In 1935 it was discovered that the roof timbers had rotted badly. The roof structure was so weakened that it became necessary to remove the entire roof and replace with steel trusses.

The repair consisted of an addition to the ceiling of the pool with 1 in. cork block, back-coated with asphalt. The exhaust registers in the ceiling over the pool were enclosed and the exhaust conducted through the roof by ducts. These

CONSERVATION
FOR VICTORY

ducts were insulated with asphalt-impregnated cork so as to prevent the collection of moisture.

The heating of the pool space was conducted much as before and this resulted in some deposition of moisture on the steel trusses and the roof boards particularly at the eaves. This was strikingly visible on very cold days, when heavy frost collected on these trusses.

More Repairs

In 1938 it became necessary to make other extensive repairs on the building. In the course of this reconstruction, the direct radiation was replaced due to corrosion. The original direct radiation was completely enclosed, with masonry slots being left at the floor and at the top of the radiators for circulation of air; the new direct radiation was installed completely exposed and accessible.

The ducts leading from the basement unit heaters were modified so that a portion of the heat from each unit heater was conducted to the attic. These changes resulted in more uniform temperatures in the pool area and somewhat reduced the moisture deposit in the attic space.

In 1939, additional modifications were made. The unit heater ducts were altered so that the unit heater in the north end of the building serves the attic space only, while the unit heater at the other end of the building serves the pool space only.

Humidistat Used

With the attic supply at the north end of the building, and three exhaust dampers at the eave on the south end of the attic space, the entire length of the attic space is scoured by the unit heater supply. A humidistat centrally situated in the attic controls the operation of the north unit heater. This control actuates the inlet supply when the moisture content of the air in the attic reaches 58 per cent relative humidity, and shuts off the unit heater when the moisture content reaches 50 per cent. The exhaust dampers open when the fan is in operation and close as soon as the operation is completed.

This cycle has solved our difficulties. Very little corrosion is taking place in the metal work and ordinary maintenance, painting and care—coupled with good housekeeping—should keep this roof intact indefinitely.

Condition of roof timbers after roof was removed showing weakening of roof supports because of timber deterioration

ELECTRIC HEAT APPLICATIONS

The Editor—

I certainly agree with the general discussion of Siegfried Ruppright in the November HPAC regarding the need for heat in a great many cases where piping or vessels are exposed to temperatures below that suitable for the handling of their contents. The best application of electric heat would depend entirely upon the circumstances. The variable conditions are the voltage and type of power supply available, the necessary temperature in order to maintain proper conditions and external conditions which affect the protection of the heating elements. Obviously, the same design would not be satisfactory for a 550 volt service as for 110 volts, because of insulation differences. Also, an outdoor installation or one buried underground could not be handled the same as one in a well protected room. Another situation which must be given careful study is whether an overflow of fluid from a tank, or a leak in a pipe, might come in contact with the heating means and cause trouble.

Wattages

Undoubtedly there are some cases where copper wire could be used as a resistance medium with satisfactory results, but in a great many cases a material which stands higher temperatures would be absolutely necessary. I rather question the wisdom of giving specific figures of watts per foot of pipe, without also stating at the same time all the conditions affecting the service. That wattage might be satisfactory to prevent freezing of water in insulated pipe lines but that again depends upon the external temperatures. On the other hand, it might not be enough to keep the heavy pitches or greases fluid enough to handle; it certainly would not be enough to keep lead or tin fluid enough to pump through molding machines.—Lee P. Hynes, Hynes Electric Heating Co., and member of HPAC's board of consulting and contributing editors.

ANNOUNCEMENT!

7th INTERNATIONAL HEATING AND VENTILATING EXPOSITION POSTPONED

Following is an official statement released to Heating, Piping and Air Conditioning on January 7 by International Exposition Co.:

> ***"The serious emergency created by the recent sudden turn of events in the world has made it advisable to postpone the 7th International Heating and Ventilating Exposition which was scheduled to open at Philadelphia on January 26 of this year.***
>
> ***"Conditions facing the heating, ventilating and air conditioning industry, the limitations necessarily placed on production for civil use, and the all-out effort to war-condition the Nation have caused manufacturers to feel that exhibiting at this time would detract from the war effort. A poll of all exhibitors indicated that the majority favored discontinuance of the Exposition.***
>
> ***"In view of this situation, the Advisory Committee has approved the postponement of the Exposition. This action is endorsed by the Management of the Exposition and will permit all exhibitors to devote every energy to the work of preparing for Victory at the earliest moment possible."—(Signed)* 7th International Heating and Ventilating Exposition, *International Exposition Co.***

Editor's Note: **This issue of Heating, Piping and Air Conditioning was made up, a number of forms were on the presses and the rest about to run when, several days before this official announcement, it was first learned that exhibitors were being polled as to whether they wished to proceed with or postpone the Exposition in Philadelphia. With the final decision in doubt until January 7, it was necessary to publish the issue as originally planned, reserving this special insert means of confirming or withdrawing the information about the Exposition it contains in the following pages. It is, of course, hereby withdrawn.**

The postponement of the Exposition means minor changes in the programs of the American Society of Heating and Ventilating Engineers and the National Warm Air Heating and Air Conditioning Association. It does not mean that these meetings are called off. The ASHVE will now hold all its sessions at the hotel; the revised program is published on the next page. The Warm Air group, per telegram from the association's managing director, will proceed as scheduled except for any activities originally planned in connection with the Exposition.

Any other references to the Exposition throughout the issue, in both editorial and advertising pages, are, of course, qualified by this announcement. It will be obvious that, while the "Show" was set up to be an important feature, its discontinuance in no other way affects the value of this, the largest issue ever published by Heating, Piping and Air Conditioning. Its annual Directory, completely up to date for 1942 and running more pages than ever before, its technical articles and other editorial and advertising features have, as every year, no relationship to the Exposition.

REVISED PROGRAM FOR ASHVE MEETING

Following is the revised program announced January 7 for the 48th annual meeting of the American Society of Heating and Ventilating Engineers, Bellevue-Stratford, Philadelphia. It supersedes the program on pp. 44-45.

Sunday, January 25

9:00 a. m.—Registration (*Planet Room*—Bellevue-Stratford).

1:30 p. m.—Council Meeting (*Blue Room*).

4:00 p. m.—Final Meeting of 1941 Committee on Research (*Blue Room*).

7:45 p. m.—Planetarium (Assemble in *Planet Room*).

Monday, January 26

8:30 a. m.—Registration (*Planet Room*—Lobby Floor—Bellevue-Stratford).

9:30 a. m.—Business Session—ASHVE Members only (*Rose Room*—18th Floor—Bellevue-Stratford).
- Report of Council.
- Report of Treasurer.
- Report of Secretary.
- Report of Committee on Research, A. E. Stacey, Jr., *Chairman.*
- Report of Guide Publication Committee, C. M. Humphreys, *Chairman.*
- Report of Tellers of Election.
- Report of Committee to Study the Method of Selecting Society Officers and Council Members, by H. H. Erickson, *Chairman.*
- Amendment to By-Laws.

11:30 a. m.—Adjournment.

12:15 p. m.—Get-together Luncheon (*Clover Room*—Bellevue-Stratford).

2:00 p. m.—Technical Session (*Rose Room*).
- Panel Heating and Cooling Performance Studies, by B. F. Raber and F. W. Hutchinson.
- Radiation as a Factor in the Feeling of Warmth in Convection, Radiator and Panel Heated Rooms, by F. C. Houghten, Carl Gutberlet and E. C. Hach.
- Periodic Heat Flow in Building Walls Determined by Electrical Analogy Method, by Victor Paschkis.
- Heat Gain Through Walls and Roof as Affected by Solar Radiation, by F. C. Houghten, E. C. Hach, S. I. Taimuty and Carl Gutberlet.

8:00 p. m.—Technical Session (*Clover Room*—Bellevue-Stratford).
- Comfort with Summer Air Conditioning, by Technical Advisory Committee on Sensations of Comfort, Thomas Chester, *Chairman.*
- Use of Cold Accumulators in the Air Conditioning Field, by R. W. Evans and C. J. Otterholm.
- The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and Albert F. Poor.

Tuesday, January 27

9:30 a. m.—Technical Session (*Rose Room*—18th Floor—Bellevue-Stratford).
- Performance of a Hot-Water Heating System in Research Home, by A. P. Kratz, M. K. Fahnestock, W. S. Harris and R. J. Martin.
- Factors Influencing the Heat Output of Radiators, by A. C. Davis, W. N. Sawdon and David Dropkin.
- A Comparative Study of the Friction-Heads in Screwed and Welded Elbows, by F. E. Giesecke and J. S. Hopper.
- Design and Performance of Direct-Fired Unit Heater, by R. M. Rush and H. A. Pietsch.

12:15 p. m.—Organization Meeting 1942 Committee on Research.

2:00 p. m.—Technical Session (*Clover Room*).
- Corrosion Tests in a Water-Recirculating Air Conditioning System, by W. Z. Friend.
- Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr.
- Determining Sound Attenuation in Air Conditioning Systems, by D. A. Wilbur and R. F. Simons.
- The Performance of Stack Heads Equipped with Grilles, by D. W. Nelson, D. H. Lamb and G. E. Smedberg.

6:30 p. m.—Past President's Dinner.

7:30 p. m.—Meeting of Chapter Delegates (*Pink Room*).

8:30 p. m.—An Evening of Magic—Paul Fleming & Company.

Wednesday, January 28

9:30 a. m.—Technical Session (*Rose Room*—18th Floor—Bellevue-Stratford).
- The Vapor Pressure of Ice from 32 to –280 F, by John A. Goff.
- Physiological Fatigue from Exposure to Hot Environments, by M. B. Ferderber, M. D., F. C. Houghten and W. L. Fleisher.
- Physiological Influence of Atmospheric Humidity, by Technical Advisory Committee on Physiological Reactions, C.-E. A. Winslow, *Chairman.*
- Sanitary Ventilation, by W. F. Wells.

2:00 p. m.—Joint Session with National Warm Air Heating and Air Conditioning Association (*Rose Room*).
- Address:—Smoke Control, by R. R. Tucker, Smoke Commissioner, City of St. Louis.
- Pressure Loss Caused by Elbows in 8-in. Round Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts.
- Observed Performance of Some Experimental Chimneys, by Richard S. Dill, Paul R. Achenbach and Jesse T. Duck.
- Heat Loss Through Basement Walls and Floors, by F. C. Houghten, S. I. Taimuty, Carl Gutberlet and C. J. Brown.

7:00 p. m.—Annual Banquet (*Ballroom*—Bellevue-Stratford).
- Speaker, Dr. Stanley High, "What Are We Fighting For and Against?"
- Presentation of F. Paul Anderson Medal to Dr. F. E. Giesecke by Thornton Lewis.
- Installation of Officers.
- Presentation of Past President's Emblem to W. L. Fleisher by W. H. Driscoll.

Thursday, January 29

9:30 a. m.—Organization Meeting of Council (*Blue Room*).

Committee Meetings

Sunday, January 25

1:30 p. m.—Council Meeting (*Blue Room*).

4:00 p. m.—Final Meeting 1941 Committee on Research (*Blue Room*).

8:00 p. m.—Technical Advisory Committee on Cooling Towers (*Room* 104).

8:00 p. m.—Technical Advisory Committee on Sound Control (*Room* 105).

Monday, January 26

2:00 p. m.—Technical Advisory Committee on Air Distribution and Air Friction (*Room* 104).

8:00 p. m.—Committee on Code for Air Cleaning Devices (*Room* 104).

Tuesday, January 27

9:30 a. m.—Technical Advisory Committee on Air Conditioning Requirements of Glass (*Room* 105).

12:15 p. m.—Organization Meeting 1942 Committee on Research (*Blue Room*).

7:30 p. m.—Technical Advisory Committee on Corrosion (*Room* 104).

7:30 p. m.—Technical Advisory Committee on Radiation and Comfort (*Room* 105).

7:30 p. m.—Technical Advisory Committee on Heat Requirements of Buildings (*Room* 106).

7:30 p. m.—Chapter Delegates' Conference (*Pink Room*).

8:00 p. m.—Technical Advisory Committee on Sensations of Comfort.

Wednesday, January 28

8:00 a. m.—Technical Advisory Committee on Instruments (*Room* 104).

9:30 a. m.—Technical Advisory Committee on Fuels (*Room* 105).

2:30 p. m.—Nominating Committee (*Blue Room*).

3:00 p. m.—Technical Advisory Committee on Heat Transfer of Finned Tubes (*Room* 104).

Thursday, January 29

9:30 a. m.—Organization Meeting of Council (*Blue Room*).

Special Events for Ladies

Sunday, January 25

7:45 p. m.—Leave Bellevue-Stratford for Planetarium.

Monday, January 26

3:30 p. m.—Tea and Musical Entertainment.

Tuesday, January 27

10:30 a. m.—Sightseeing trips to Historic Spots in Philadelphia and Luncheon at General Wayne Inn, Valley Forge.

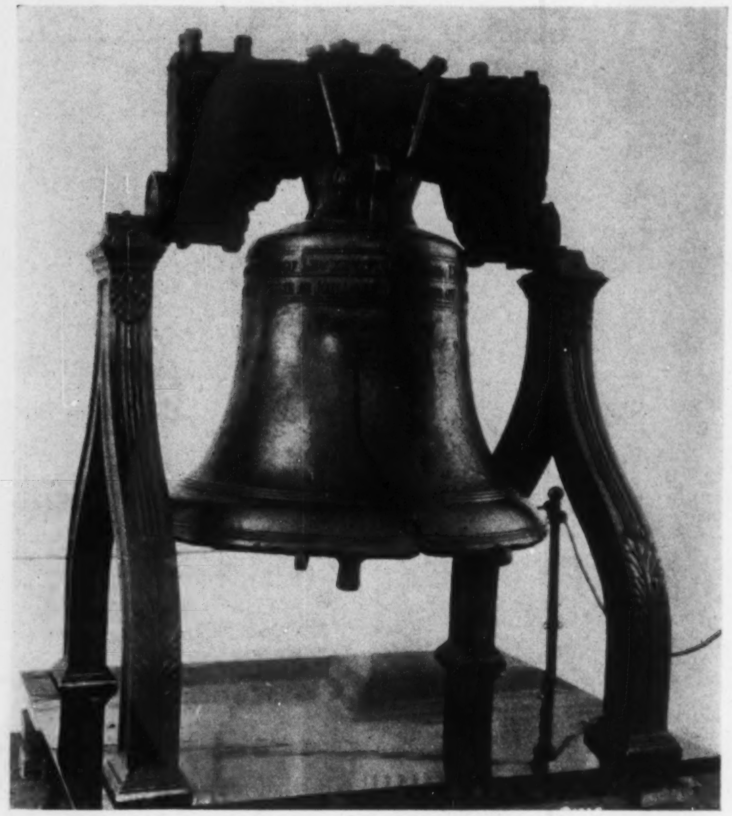
Wednesday, January 28

10:45 a. m.—Breakfast-Bridge (Assemble in *Planet Room*—Lobby Floor—Bellevue-Stratford).
Franklin Institute and Art Museum.

PHILADELPHIA

JANUARY 26-30, 1942

Host City to the 48th Annual Meeting of the American Society of Heating and Ventilating Engineers . . . . . 28th Annual Convention of the National Warm Air Heating and Air Conditioning Association . . . . . Seventh International Heating and Ventilating Exposition



Liberty Bell, symbol of freedom, housed in Philadelphia's Independence Hall

INDUSTRY CARRIES ON

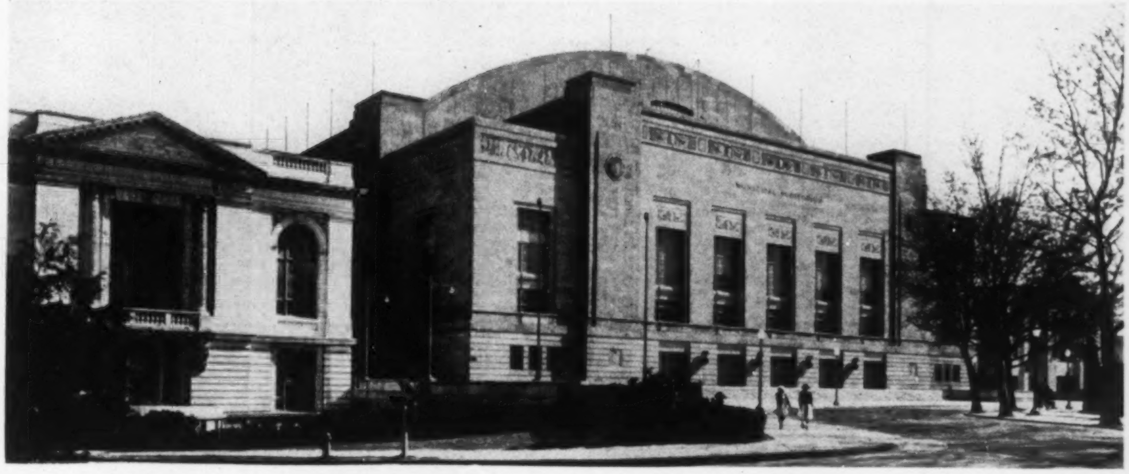
WHEN plans were made more than a year ago for the Philadelphia meeting of the Society, the annual convention of the Warm Air Association and the biennial Heating and Ventilating Exposition there had been no Pearl Harbor. Now, within the last 30 days, the United States has become an active belligerent in an all-out world-wide war against the Axis powers; and the dates for these big events of the industry have approached in the midst of the first shock and realization of the tremendous task our country faces.

Fully conscious of the situation created, and after careful deliberation as to the proper step to take, the officers of the Society and Association and the management of the Exposition had, at the time of going to press with this issue, decided to carry on with the original plans. The information presented in these and following pages—programs of the meetings, lists of exhibitors, layout of the exhibit hall and other news of the industry's big week in Philadelphia, January 26-30—covered these plans as released by the authorities in charge. Should any major changes be called for before mailing, some means of notifying our readers will be adopted.

It will be noted that it is the 48th annual meeting of the American Society of Heating and Ventilating Engineers, with headquarters at the Bellevue-Stratford. It is the 28th annual convention of the National Warm Air Heating and Air Conditioning Association, with headquarters at the Benjamin Franklin. It is the Seventh International Heating and Ventilating Exposition, set up in Commercial Museum, 34th near Spruce.

The Society will be on the job from Monday, the 26th, right through Thursday, the 29th, with technical sessions in the mornings at the Bellevue-Stratford and in the afternoons in the Ballroom at the Exposition. On Friday several inspection trips have been planned. Entertainment on Monday, Tuesday and Wednesday evenings has been arranged by the Philadelphia Chapter, the annual banquet closing out the ceremonies Wednesday night. Special events for the ladies will keep them busy, interested and happy throughout the week.

For the Society, M. F. Blankin is general chairman of the Committee on Arrangements, with H. Berkley Hedges and C. B. Eastman vice-chairmen and R. D. Touton secretary. Mrs. M. F. Blankin is in charge of the affairs for the ladies. Other committee chairmen are Karl Rugart, hotels; J. H. Hucker, publicity; W. P. Culbert, entertainment; H. H. Erickson, banquet; L. A. Childs, transportation; E. H. Dafter, inspections; A. C. Caldwell, finance; R. F. Hunger, sessions; and H. H.



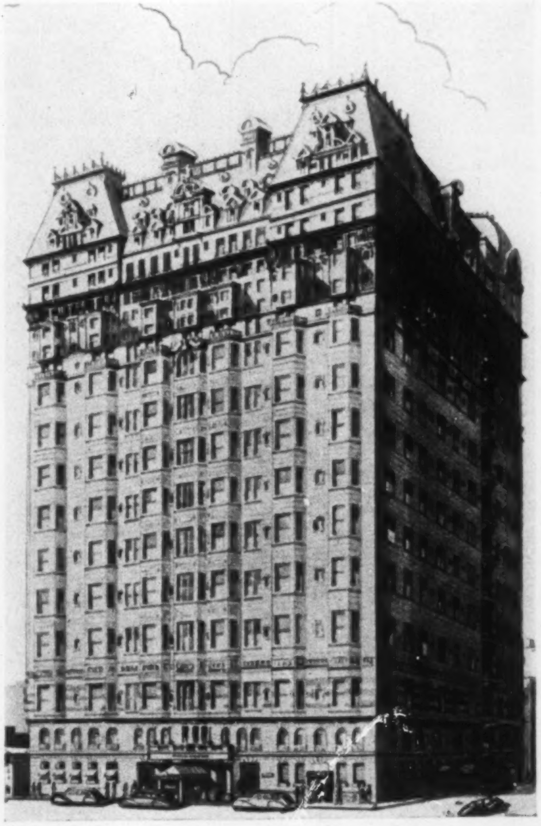
Commercial Museum and Municipal Auditorium

Mather, reception and registration. The honorary committee comprises Homer Addams, G. W. Barr, J. D. Cassell and A. W. Luck.

In the program of the National Warm Air Heating and Air Conditioning Association, the arrangements have been to focus on the problems and conduct of the industry's business in the year of 1942. The war situation will be dominant and Managing Director Boeddener states that this meeting will provide an opportunity to learn just what is being experienced and what may be expected in industry activities under war conditions. Wednesday will be given over to technical sessions which provide for a joint meeting with the Society in the afternoon.

The sponsors and management of the Exposition feel that many adjustments which defense industries must make immediately under the new war status will be speeded up through contacts and conferences at the Exposition. They point out that heating and ventilating are essential to the smooth working of defense industries, now on a 24 hour basis and a seven day week in many instances, and air conditioning is an absolute requisite to a number of process steps in the production of critical materials. Priorities, shortages, substitutions of materials, diversion of products out of normal channels and into the war routine have created situations which, it is felt, can most promptly be analyzed and harmonized by bringing together suppliers of materials, manufacturers and consumers at one time and place.

Such a meeting ground the Exposition will provide. It is scheduled to open at 2:00 p. m. on Monday, January 26, and to be open daily thereafter until January 30, from 12 noon until 10:30 p. m.



To Left—Bellevue-Stratford, Headquarters, ASHVE

To Right — Benjamin Franklin, Headquarters, NWAHACA

Programs for the Meetings

48th Annual Meeting

American Society of Heating and Ventilating Engineers—Bellevue-Stratford

Sunday, January 25

9:00 a. m.—Registration (*Planet Room*—Bellevue-Stratford).
10:00 a. m.—Council Meeting.
3:00 p. m.—Final Meeting of 1941 Committee on Research.
7:45 p. m.—Planetarium.

Monday, January 26

8:30 a. m.—Registration (*Planet Room*—Lobby Floor—Bellevue-Stratford).

9:30 a. m.—Business Session—ASHVE Members only (*Rose Room*—18th Floor—Bellevue-Stratford).

Report of Council.

Report of Treasurer.

Report of Secretary.

Report of Committee on Research, A. E. Stacey, Jr., Chairman.

Report of Guide Publication Committee, C. M. Humphreys, Chairman.

Report of Tellers of Election.

Report of Committee to Study the Method of Selecting Society Officers and Council Members, by H. H. Erickson, Chairman.

Amendment to By-Laws.

11:30 a. m.—Adjournment.

2:00 p. m.—Opening of 7th International Exposition (Commercial Museum—34th Street near Spruce).

2:30 p. m.—Technical Session (*Ballroom* at the Exposition).
Panel Heating and Cooling Performance Studies, by B. F. Raber and F. W. Hutchinson.
Radiation as a Factor in the Feeling of Warmth in Convection, Radiator and Panel Heated Rooms, by F. C. Houghten, Carl Gutberlet and E. C. Hach.
Periodic Heat Flow in Building Walls Determined by Electrical Analogy Method, by Victor Paschkis.
Heat Gain Through Walls and Roof as Affected by Solar Radiation, by F. C. Houghten, E. C. Hach, S. I. Taimuty and Carl Gutberlet.

7:30 p. m.—Organization Meeting 1942 Committee on Research.

7:30 p. m.—Meeting of Chapter Delegates.

Tuesday, January 27

9:30 a. m.—Technical Session (*Rose Room*—18th Floor—Bellevue-Stratford).
Performance of a Hot-Water Heating System in Research Home, by A. P. Kratz, M. K. Fahnestock, W. S. Harris and R. J. Martin.
Factors Influencing the Heat Output of Radiators, by A. C. Davis, W. N. Sawdon and David Dropkin.
A Comparative Study of the Friction-Heads in Screwed and Welded Elbows, by F. E. Giesecke and J. S. Hopper.
Design and Performance of Direct-Fired Unit Heater, by R. M. Rush and H. A. Pietsch.

12:00 noon—Exposition (Commercial Museum).

2:00 p. m.—Technical Session (*Ballroom* at the Exposition).
Corrosion Tests in a Water-Recirculating Air Conditioning System, by W. Z. Friend.
Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr.
Determining Sound Attenuation in Air Conditioning Systems, by D. A. Wilbur and R. F. Simons.
The Performance of Stack Heads Equipped with Grilles, by D. W. Nelson, D. H. Lamb and G. E. Smedberg.

Wednesday, January 28

9:30 a. m.—Technical Session (*Rose Room*—18th Floor—Bellevue-Stratford).
The Vapor Pressure of Ice, by John A. Goff.
Physiological Fatigue from Exposure to Hot Environments, by M. B. Ferderber, M. D., F. C. Houghten, and W. L. Fleisher.
Physiological Influence of Atmospheric Humidity, by Technical Advisory Committee on Physiological Reactions, C.-E. A. Winslow, *Chairman*.
Sanitary Ventilation, by W. F. Wells.

12:00 noon—Exposition (Commercial Museum).

2:00 p. m.—Joint Session with National Warm Air Heating and Air Conditioning Association (*Ballroom* at the Exposition).
Pressure Loss Caused by Elbows in 8-in. Round Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts.
Observed Performance of Some Experimental Chimneys, by Richard S. Dill, Paul R. Achenbach and Jesse T. Duck.
Heat Loss Through Basement Walls and Floors, by F. C. Houghten, S. I. Taimuty, Carl Gutberlet and C. J. Brown.

7:00 p. m.—Annual Banquet (*Ballroom*—Bellevue-Stratford).

Thursday, January 29

10:00 a. m.—Technical Session (*Rose Room*—18th Floor—Bellevue-Stratford).
Comfort with Summer Air Conditioning, by Technical Advisory Committee on Sensations of Comfort, Thomas Chester, *Chairman*.
Use of Cold Accumulators in the Air Conditioning Field, by R. W. Evans and C. J. Otterholm.
The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and Albert F. Poor.
Installation of Officers.

12:00 noon—Exposition (Commercial Museum).

12:30 p. m.—Organization Meeting of Council.

COMMITTEE MEETINGS

Sunday—January 25

1:30 p.m. Council Meeting (*Blue Room*)
4:00 p.m. Final Meeting 1941 Committee on Research (*Blue Room*)
8:00 p.m. Technical Advisory Committee on Cooling Towers
8:00 p.m. Technical Advisory Committee on Sound Control

Monday—January 26

7:30 p.m. Organization Meeting 1942 Committee on Research (*Blue Room*)
7:30 p.m. Chapter Delegates' Conference (*Pink Room*)
8:00 p.m. Committee on Code for Air Cleaning Devices (*Room* 104)

Tuesday—January 27

9:00 a.m. Technical Advisory Committee on Air Distribution and Air Friction (*Room* 104)
9:30 a.m. Technical Advisory Committee on Air Conditioning Requirements of Glass (*Room* 105)
7:30 p.m. Technical Advisory Committee on Corrosion (*Room* 104)
7:30 p.m. Technical Advisory Committee on Radiation and Comfort (*Room* 105)
7:30 p.m. Technical Advisory Committee on Heat Requirements of Buildings

Wednesday—January 28

8:00 a.m. Technical Advisory Committee on Instruments (*Room* 104)
9:00 a.m. Technical Advisory Committee on Fuels (*Room* 105)
2:30 p.m. Nominating Committee (*Blue Room*)
3:00 p.m. Technical Advisory Committee on Heat Transfer of Finned Tubes (*Room* 104)

Thursday—January 29

12:30 p.m. Organization Meeting of Council

SPECIAL EVENTS FOR LADIES

Sunday

7:45 p.m. Leave Bellevue-Stratford for Planetarium

Monday

3:30 p.m. Tea and Musical Entertainment

Tuesday

10:30 a.m. Sightseeing trips to Historic Spots in Philadelphia and Luncheon at General Wayne Inn, Valley Forge

Wednesday

10:45 a.m. Breakfast-Bridge (Assemble in *Planet Room*—Lobby Floor—Bellevue-Stratford)
Franklin Institute and Art Museum.

COMMITTEE ON ARRANGEMENTS

M. F. Blankin, *General Chairman*

H. Berkley Hedges, *Vice Chairman*
R. D. Touton, *Secretary*
C. B. Eastman, *Vice-Chairman*

Honorary Committee
(*Life Members*)

Homer Addams
G. W. Barr
J. D. Cassell
A. W. Luck
C. V. Haynes

Hotels: Karl Rugart, *Chairman*
Publicity: J. H. Hucker, *Chairman*
Entertainment: W. P. Culbert, *Chairman*
Ladies: Mrs. M. F. Blankin, *Chairman*
Banquet: H. H. Erickson, *Chairman*
Transportation: L. A. Childs, *Chairman*
Inspections: E. H. Dafter, *Chairman*
Finance: A. C. Caldwell, *Chairman*
Sessions: R. F. Hunger, *Chairman*
Reception and Registration: H. H. Mather, *Chairman*

28th Annual Meeting

National Warm Air Heating and Air Conditioning Association — Benjamin Franklin Hotel

Tuesday, January 27—Crystal Ball Room

9:30 a. m. E. S. T., President C. A. Olsen, Chairman.

President's Message, C. A. Olsen.

Our Country, Representative of the National Manufacturers' Association.

Building Construction Industry in 1942, Thomas S. Holden, President, F. W. Dodge Corp.

Our Industry's Objectives and Responsibilities in the War Effort, W. L. McGrath, Member Plumbing and Heating Industry Defense Advisory Committee.

2:00 p. m. E. S. T., H. S. Sharp, Chairman.

Objectives and Functions of Emergency Committee, I. L. Jones, Chairman, Emergency Committee of the Warm Air Furnace Manufacturing Industry.

Simplification and Elimination of Waste, P. S. Miller, Chairman, Elimination of Waste Committee.

Defense Housing Priorities, OPM Representative.

Product Requirements Plan, OPM Representative.

Contract Distribution, OPM Representative.

9:30 p. m.—ASHVE "Evening of Magic." Two-Hour Show by Paul Fleming and Co. Ball Room, Bellevue-Stratford Hotel.

Wednesday, January 28—Garden Terrace.

9:30 a. m. E. S. T., F. G. Sedgwick, Chairman.

Our Research Activities and Cooperative Effort with Our Government, F. G. Sedgwick, Chairman, Research Advisory Committee.

Our Codes—Today and Tomorrow, W. D. Redrup, Chairman, Installation Codes Committee.

Oil Test Code, Professor A. P. Kratz, University of Illinois.

Standard Code Application Manual, Professor S. Konzo.

Short Course, Professor Lorin G. Miller, Michigan State College.

Election of Officers.

2:00 p. m. E. S. T., Joint Session with American Society of Heating and Ventilating Engineers, Ball Room at the Commercial Museum.

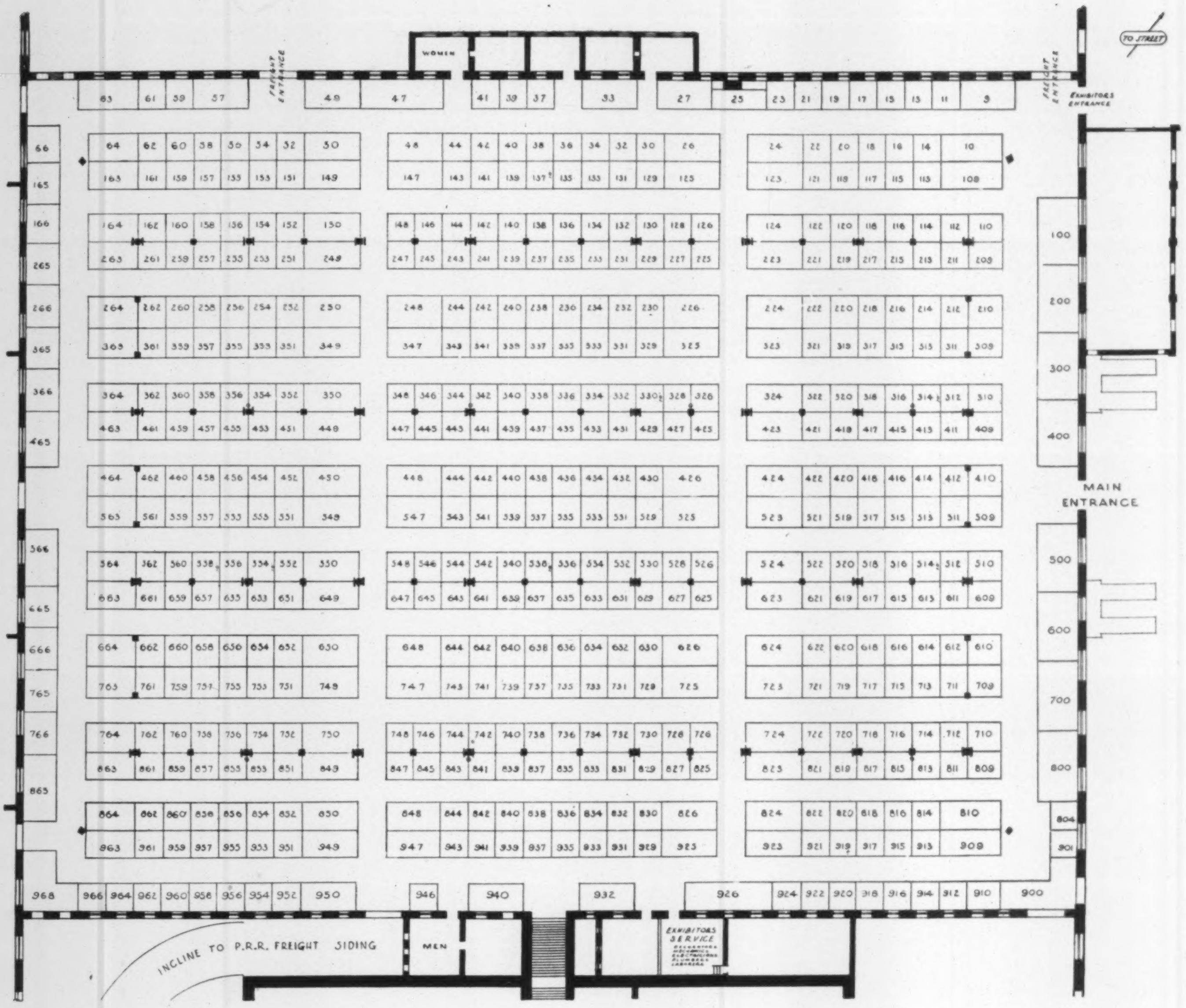
Presiding, C. A. Olsen, President, National Warm Air Heating and Air Conditioning Association. W. L. Fleisher, President, American Society of Heating and Ventilating Engineers.

Pressure Loss Caused by Elbows in 8-in. Round Ventilating Duct, M. C. Stuart, C. F. Warner and W. C. Roberts.

Observed Performance of Some Experimental Chimneys, Richard S. Dill, Paul R. Achenbach and Jesse T. Duck.

Heat Loss Through Basement Walls and Floors, F. C. Houghten, S. I. Taimuty, Carl Gutberlet and C. J. Brown.

Adjournment.


TO STREET
WOMEN
FREIGHT ENTRANCE
FREIGHT ENTRANCE
EXHIBITORS ENTRANCE
MAIN ENTRANCE
MEN
EXHIBITORS SERVICE
INCLINE TO P.R.R. FREIGHT SIDING

Layout of Commercial Museum showing the booth locations

EXPOSITION EXHIBITORS AND THEIR EXHIBITS

Listed below are the names of the exhibitors who are scheduled for the Seventh International Heating and Ventilating Exposition, per latest advice at press time from the exposition management. Those listed with information on the products they will exhibit and the names of representatives who will be in attendance furnished these details direct to HEATING, PIPING AND AIR CONDITIONING. With the booth numbers and the accompanying diagram of the exhibit hall, the location of each exhibitor can be quickly spotted.

A glance through this list shows that war demands for products of this industry are reflected in many of the exhibits. Manufacturers plan to show the equipment they have developed and adapted for defense plant, military and housing needs. Visitors should find this an opportunity to see and discuss the effect of war upon heating, ventilating, air conditioning and piping practice.

The exposition is under the management of International Exposition Co., Inc., New York, N. Y., Charles F. Roth, manager.

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Aerofin Corp., Syracuse, N. Y.	532		Heating and Cooling Surface
Air & Refrigeration Corporation, New York, N. Y.	716-718-720	D. C. Lindsay, H. S. Dutcher, J. L. Blackshaw	Capillary Unit Air Conditioner
Air Conditioning & Oil Heat, New York, N. Y.	923		Publication
Air Controls, Inc., Div. of The Cleveland Heater Co., Cleveland, Ohio	324	B. G. Krause, G. L. Schwarz, S. S. Minnich, Chas. E. Rainsbury, Arthur Friedman	Blowers and Parts; Blower-Filter Units; Ventilating Equipment
Air Devices, Inc., New York, N. Y.	365		Air Diffusers
Air-Maze Corporation, Cleveland, Ohio	348	F. M. Paul, H. M. Flaherty, C. B. Moorhead, P. C. Hungerford, Geo. J. Gardner, Geo. Knaab	Permanent Air Filter Panels; Filters for Range Canopies
Airtemp Division, Chrysler Corp., Dayton, Ohio	900-910-912-914-916		
Airtherm Mfg. Co., St. Louis, Mo.	237	Edwin Elliot & Co.	Unit Heaters and Warm Air Heaters
Aldrich Co., Wyoming, Ill.	126-128-130-132		Oil Burners
Allis-Chalmers Mfg. Co., Milwaukee, Wis.	533-535-537-434-436-438		Motors, V-belts, Electrifugal Pumps
Aluminum Aircell Insulation Co., Detroit, Mich.	829	L. M. Payne, L. V. Goebbels	Insulation
American Air Filter Co., Inc., Louisville, Ky.	700	H. C. Murphy, H. W. Pound, G. W. Sonntag, J. H. Hucker, L. A. Pryibil, F. F. Espenscheid, F. C. Clifford, W. C. Kruze, J. F. Reed, J. M. Pettingel, P. F. Chartres, G. A. Stevens, J. D. Reed	Complete line of air filtering equipment
American Artisan, Chicago, Ill.	226	F. P. Keeney, J. D. Wilder, W. J. Osborn, R. A. Jack, R. P. Wettstein, C. E. Price, J. D. Thomas	Publication
American Brass Co., Waterbury, Conn.	715-717-719		Copper tubes and fittings, welded boilers, vibration eliminators, welding rods. Also, displays of raw, semi-finished and finished defense products.
American Gas Association, New York, N. Y.	636-644 and 735-743		Airtemp Div., Chrysler Corp., American Radiator & Standard Sanitary Corp., Automatic Gas Equipment Co., Bryant Heater Co., Burnham Boiler Co., Clow Gasteam Heating Co., Detroit Lubricator Co., Forest City Foundries Co., General Controls Co., Handley Brown Heater Co., Henry Furnace & Foundry Co., Hook & Ackerman Mfg. Co., Mueller Furnace Co., Oakland Foundry Co., Ohio Foundry & Mfg. Co., Perfection Stove Co., Philadelphia Gas Works Co., Richmond Radiator Co., Roberts-Gordon Appliance Co., Surface Combustion Corp., White-Rodgers Elec. Co.
American Radiator and Standard Sanitary Corp., Pittsburgh, Pa.	956-968		Furnaces, Winter Air Conditioners, Boilers, Radiators, Oil Burners and Heating Accessories
American Rolling Mill Co., Middletown, Ohio	343-347	T. I. Byrd, Nicholas Tiedeman	A miniature plant that will enable visitors to compare the paint-adhering qualities of ordinary galvanized sheet metal and a special bonderized galvanized sheet
American Society of Heating & Ventilating Engineers, New York, N. Y., and Pittsburgh, Pa.			Society and research activities
American Steel & Wire Co., Chicago, Ill.	648-747	L. L. Anderson, G. R. Watts, H. B. Taylor	See United States Steel Corp.
American Stove Co., Lorain Div., Lorain, O.	21-23		

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Ames Hydrovac Corp., Brooklyn, N. Y.	20-22	Chas. F. Ames, Pat Savage	Heating System Pumps
Anderson Co., V. D., Cleveland, Ohio	548		Steam Traps; Pipe Line Strainers
Anderson Products, Inc., Cambridge, Mass	332	W. T. Ferguson, J. M. Blanchard, K. G. Agnew, K. B. Gerrish, R. D. Bitzer, Vernon Bitzer	Air Valves, featuring their reconditioning
Anemostat Corporation of America, New York, N. Y.	600	M. Sheffler, S. S. Gross, F. J. Kurth, A. Rust-Oppenheim, V. Floyd Self	High Velocity Air Diffusers, Ceiling and Wall; Combination Diffusers and Built-In Lighting Units
Armstrong Machine Works, Three Rivers, Mich.	643-645	O. E. Ulrich	Steam Traps; Steam-type Humidifiers
Arnold Sales & Engineering Co., Robert, Philadelphia, Pa.	215		See H. O. Trerice Co.
Auto-Heat Corp., New York, N. Y.	140-142-144	Otto B. Moody, J. B. Bernhard	Oil Burners; Cast Iron and Steel Boiler-Burner Units and Air Conditioning Units
Automatic Burners Corp., Chicago, Ill	865		
Automatic Humidifier Co., Cedar Falls, Ia.	641	J. W. Galloway, Mrs. Roger M. Galloway, L. W. Reining, Roger M. Galloway, Earl Newville	Humidifiers
Barber-Colman Co., Rockford, Ill.	418-420	D. J. Stewart, C. J. Braatz, L. C. Plaehn, T. K. Greenlee, R. P. Dewey, D. R. Farquhar, E. A. Greenlee, H. E. Shugars	Grilles and Registers; Overhead Diffusers; Electric Controls
Barnes & Jones, Inc., Jamaica Plain, Boston, Mass.	710	J.T. H. Anderson, H. B. Ells.	Vapor and vacuum heating specialties
Beaver Pipe Tools, Inc., Warren, Ohio	804-901		Tools
Bell & Gossett Co., Chicago, Ill	366-465	E. J. Gossett, R. E. Moore, C. E. Pullum, R. D. Bitzer, R. A. Patterson, E. L. Malm, Walter Lige, Frank Hackett	A complete line of specialties for forced hot water house heating and domestic water heating.
Bethlehem Foundry & Machine Co., Bethlehem, Pa.	922-924	J. B. White, C. L. White, P. A. Mariette, C. S. Dieter	Oil Burning Heating Equipment
Bethlehem Steel Co., Bethlehem, Pa.	323		Steel Products
Black & Decker Mfg. Co., Towson, Md	240-242	E. H. Federschmidt, R. H. Herrick, Frank Cassidy, G. B. Buchanan, J. F. Apsey, Jr.	Portable Electric Tools
Brown Instrument Co., Philadelphia, Pa.	810-814-909-913		Industrial Controls
Bryant Heater Co., Cleveland, Ohio	450-452-549-551	D. E. Leslie, C. F. Cushing, H. W. Heisterkamp, J. N. Crawford, C. H. Cummings	Gravity Furnace, Forced Air Furnace, Winter Air Conditioner, Hot Water Boiler, Steam Boiler, Conversion Burner, Unit Heater, Dehumidifier, Coke Stoker
Burnham Boiler Corp., Irvington, N. Y.	300	A. A. Miller, C. W. Lowrey, A. H. MacDade, J. J. Hogan, H. R. Way, J. Balter	Boilers and Radiators
Byers Company, A. M., Pittsburgh, Pa.	613	J. B. Fullman, J. F. Byers, Jr., F. K. Knapp, E. L. MacWhorter, H. K. King, R. R. Leonard, N. W. Hosler	Wrought Iron Products
Carbondale Division, Worthington Pump & Machinery Corp., Harrison, N. J.	622-624 721–723		Air Conditioning
Carnegie-Illinois Steel Corp., Pittsburgh, Pa.	648-747	Bennett S. Chapple, Jr., E. J. Collins, H. V. Clark, G. G. McGlaughlin, P. H. Van Pelt, H. J. Mokate, J. F. Traa, D. McHugh, J. M. Curto, C. A. Parsons, J. D. Darby, W. C. Bobbitt	See United States Steel Corp.
Carrier Corp., Syracuse, N. Y.	426-430-525-529		Air Conditioning
Century Electric Co., St. Louis, Mo	626	John E. Herron, W. L. Dively, J. Larkin, G. E. Moe, E. W. Pritchard, A. L. Smith, G. Y. Watt, J. M. Hicks, W. J. Nace, G. H. Pechin, L. H. Downing, G. C. Henderson, J. L. Woodress, E. S. Moore, A. Neher, Oliver S. Imes	Electric Motors—split phase, capacitor, repulsion start induction, squirrel cage, open, enclosed, totally enclosed, fan cooled, for all types of air conditioning equipment.
Century Engineering Corp., Cedar Rapids, Ia.	844-848	M. D. McWilliams, J. A. Lattner, Geo. K. Kelley, E. E. Scott, S. P. Densmore, A. H. Mellott, H. B. Siemon	Oil burning furnaces; water heaters; boiler-burner units; conversion oil burners.
Chace Company, W. M., Detroit, Mich	331	John C. Schwab, Thomas H. Sheehan	Thermostatic Bimetal Stampings; Formed Elements; Sub Assemblies; High Expansive Alloys
Chicago Filter Co., Joliet, Ill	218	L. D. McGrew, Ed. Berthet	Air Filters
Chicago Pump Co., Chicago, Ill.	431-433-435-437	George D. Beers, Milton Spiegel, H. E. Martin, S. K. Steiner, S. S. Whitby, W. P. Culbert, Jr., S. E. Kappe, G. L. Thom	Condensation-vacuum pumps for heating systems; condensation pumps; circulating pumps; sewage ejectors

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Cleveland Steel Products Corp., Cleveland, Ohio	850 and 949		
Coe Manufacturing Company, Painesville, Ohio	233	C. W. St. Clair	Steam Traps
Coleman Lamp & Stove Co., Philadelphia, Pa.	316-318		
Cole-Sullivan Engineering Co., Minneapolis, Minn.	713	A. D. Cole, H. J. Sewell, I. E. Loring, E. W. Laudert	Draft Governors; Draft Stabilizers; Draft Correctors; Draft Gauges; CO_2 Test Sets; Stack Thermometers; Damper Lock Sets
Commercial Filters Corp., Boston, Mass	751	E. W. Sherburne	Filters for Oil Heating
Crane Co., Chicago, Ill.	439-441-443	George Hoffman, James Dwyer, George Sherry, Clifford Rife, Clarence Stermer, William Howard, H. L. Goll, J. H. Geiss, Charles Sims, T. M. Lowe	Heating material; Valves; Fittings; Pipe
Crew Co., F. D., Philadelphia, Pa.	219-221		
Crowe Name Plate & Mfg. Co., Chicago, Ill.	951		
Dayton Rubber Manufacturing Co., Dayton, Ohio	726-728-730	K. H. Glanton, T. C. Davis, L. C. Strobeck, H. L. Boger, J. T. Wilson, T. D. Slingman, R. L. Wetzel, J. D. Hershey, A. K. Snyder, L. J. Adams, R. H. Laird, W. D. Tuck, J. W. Torrant, J. A. Denholm	New Belt for V-to-V or V-Flat Service; V-Belts
Detroit Lubricator Co., Detroit, Mich	631-633		Controls
Dole Valve Co., Chicago, Ill	518	F. M. Thomson, J. F. Lund, P. F. Gilboy	Air and Vacuum Valves; Water Mixers
Domestic Engineering, Chicago, Ill	609-611		Publication
Domestic Engineering Catalog Directory, Chicago, Ill.	609-611		Publication
Dongan Electric Mfg. Co., Detroit, Mich.	820		
Dorex Division, W. B. Connor Engineering Corp., New York, N. Y.	520-522		Odor Control Equipment; Air Diffusers
Dowagiac Steel Furnace Co., Dowagic, Mich.	200	A. F. Frazee, R. S. McNaney, L. W. Silverthorn, Graham Woodhouse, Arthur W. Wick	Defense Housing Units; Oil-fired Water Heater; Oil-fired Conditioner; "Hi-Boy" Oil-fired Conditioner; Steel Furnace with Blower for Forced Air Conditioning; Stoker-fired Furnace
Doyle Vacuum Cleaner Co., Grand Rapids, Mich.	244	Dewey I. Doyle, Ellsworth V. Bahrman, Richard E. Bird	Cleaners; Furnace Vacuum Cleaners
Dravo Corp., Pittsburgh, Pa.	116-118	S. P. Felix, Alice H. Pfeffer, R. M. Rush, M. L. Hicks, H. K. Hicks	Self-fired Unit Heaters and Heating Systems
Dunham Co., C. A., Chicago, Ill.	510-512-514-516		Heating Systems
Duo-Therm Division, Motor Wheel Corp., Lansing, Mich.	13-15-17	A. Frantz, R. H. Reeder, G. H. Phillips	Fuel Oil Burning Furnaces; Water Heaters; Space Heaters
Edison Instrument Division, Thomas A., Orange, N. J.	534	Earl R. Snavely, J. B. Campbell	Timed Relays; Sealed Thermostats; Thermostatic Steam Valves
Elliot & Co., Edwin, Philadelphia, Pa.	235		
Evans Products Co., Detroit, Mich	14-16-18		
Fairbanks, Morse and Co., Chicago, Ill	750-849	H. L. Bilsborough, J. W. Bostwick, Harry Neal Baum	Self-contained Air Conditioning Units; Window Ventilator Compressors; Anthracite Stokers; Bituminous Stokers
Fairfield Oil Heating Co., Inc., Greenwich, Conn.	25		Oil Burners
Fedders Manufacturing Co., Inc., Buffalo, N. Y.	344-346	C. E. Scott, E. R. Walker	Unit Heaters; Heating Coils; Cooling Coils
Field Control Division, H. D. Conkey & Co., Chicago, Ill.	41	C. W. Potter, W. G. Van Etten, E. A. Field, Walter Thor, Fay Kinne	Domestic and Commercial Barometric Draft Controls
Fireline Stove & Furnace Lining Co., Chicago, Ill.	32	D. J. Quinnan	Stove and Furnace Lining; Asbestos Furnace Cement; Castable Refractory Material
Fitzgibbons Boiler Co., Inc., New York, N. Y.	422-424	Paul K. Addams, R. L. Hansen, R. T. Demarest, E. N. Black, 3rd, W. C. Wetherstine, J. C. Myers	Boilers and air conditioners adaptable to defense housing requirements
Frick Co., Waynesboro, Pa.	24		
Fuel Oil Journal, Oilheating & Air Conditioning, New York, N. Y.			Publication
Fulton Sylphon Co., Knoxville, Tenn	444-448	E. D. Rogers, F. G. Cross, S. Gross, M. Sheffler, L. S. Dysart	Temperature Controls for Heating, Ventilating and Air Conditioning
General Controls Co., Glendale, Calif	249	E. T. Howard, John Hammond, H. G. Wasserlein, Wm. F. Marsh, Geo. Le Fevre	Solenoid Valves, Motorized Valves, Refrigeration Valves, Industrial Valves, Thermostats, Expansion Valves, Gas Pressure Regulators, Combustion Controls, Thermo-couple Safety Pilots, Diaphragm Valves, Switches, Strainers, Manual Reset Valves, Relays, Low Water Cutouts, Governors

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
General Electric Co., Schenectady, N. Y.	616-618-620		
General Electric Co., Air Cond. & Coml. Refrig. Dept., Bloomfield, N. J.	326-328-330 425-427-429		
Gilbert & Son, Harry E., Bridgeport, Conn.	61	Harry E. Gilbert, Carl G. Nelson, Rudolph Rehm, W. H. Williams	Radiant Arches and Domes
Gillen Company, J. L., Dowagiac, Mich	919-921	John L. Gillen, Marvin Hahn, Milton Wagner, Harry Burman	Oil Burning Water Heaters; Oil Burning Furnaces; Oil Burning Floor Furnaces
Gilmer Co., L. H., Tacony, Philadelphia, Pa.	935-937		Belts
Gray Metal Products Co., Rochester, N. Y.	230-232		
Grinnell Company, Inc., Providence, R. I.	325		Welding Fittings, C. I. Pipe Fittings, M. I. Pipe Fittings, Unit Heaters, Adjustable Pipe Hangers, Traps, Heating Specialties, Automatic Sprinklers, Valves
Guardian Utilities Co., Michigan City, Ind.	819	V. E. Malmfeldt	Flexible Couplings
Harris & Co., Arthur, Chicago, Ill	827	George C. Harris	Stainless Steel and Copper Floats
Heating, Piping & Air Conditioning, Chicago, Ill.	226	F. P. Keeney, C. E. Price, W. J. Osborn, C. M. Burnam, Jr., R. P. Wettstein, R. A. Jack, J. D. Thomas	Publication
Heating & Ventilating, New York, N. Y.	526-528		Publication
Herco Oil Burner Corp., Lancaster, Pa.	149		
Hoffman Specialty Co., Indianapolis, Ind.	566-665	Potter Bowles, M. C. Gillett, F. H. Gaylord, C. W. Stewart, Merrill F. Blankin, F. J. Ade, A. E. Kreible, C. F. Deets, Lester McCrea, H. H. Erickson, A. P. Morrow, R. Gillett, H. Grosman, F. A. Dockeray	Venting Valves, Thermostatic Traps, F. & T. Traps, Radiator Supply Valves, Hot Water Heating Systems, Vacuum and Condensation Pumps
Hotstream Heater Co., Cleveland, Ohio	150		
Ilg Electric Ventilating Co., Chicago, Ill.	524	C. W. Smith, W. W. Malloy, W. T. Trowbridge, W. C. Welde	Ventilating Fans, Blowers, Unit Heaters
Illinois Engineering Co., Chicago, Ill	165-166	Robt. L. Gifford, J. C. Matchett, J. L. Ehretsman, R. W. Leutwiler, Louis Huyette, Walter C. Edge, Phil. Wood, A. L. Browne, I. H. Geiger	Complete Selective Pressure Control System for Heating; New Motorized Valve
Illinois Testing Laboratories, Inc., Chicago, Ill.	110	J. A. Obermaier, M. D. Pugh, J. H. Torrey, R. C. Chelius	Indicating Pyrometers, Controllers, Resistance Thermometers, Air Velocity Meters
Independent Pneumatic Tool Co., Chicago, Ill.	255-257	N. C. Hurley, Jr., C. N. Kirchner, J. A. Hill, E. R. Wyler, J. Ashton, J. P. Fletcher, F. A. Herman, J. J. Murphy, A. Schuhl, A. F. Bero, A. Hjort, Jr., F. H. Charbono, J. B. Dempsey, E. R. Gee, V. G. Turner, L. Abbott, E. Hammett, W. D. Trainor	Portable Electric Drills, Sheet Metal Nibblers, Hammers, Saws, Screw and Nut Drivers, Grinders, Sanders, Polishers, Tappers
Independent Register Co., Cleveland, Ohio	231	E. C. Fox, B. N. Richardson, Blair A. Quick	Registers, Grilles and Air Flow Specialties
Industrial Device Corp., New York, N. Y.	239		
Industrial Sheet Metal Works, Inc., Detroit, Michigan	831–833	F. Lyman Pampe, Alfred W. Smart	Dust Collectors
Ingersoll Steel & Disc Division, Borg-Warner Corp., Chicago, Ill.	553–555	Charles B. Brown, Lester T. Avery, J. T. Butler, T. T. Tucker, D. D. O'Neill, Roland D. Doane	Sun Reflecting Screens
Insto Gas Corp., Detroit, Mich.	544	H. F. Belcher, R. D. Parinsobl, F. B. Larsen, John R. Robinson	Torches and Metal Melting Furnaces; Soldering Irons; Sodering Iron Furnaces, all fueled by Bottled Gas
Iron Fireman Mfg. Co., Cleveland, Ohio	926	Dale Wylie, Howard B. Evans, C. MacDonald Swan, A. A. Brumfield, J. H. Merritt, Henry P. Bachelet	Automatic coal stokers, domestic and commercial (bituminous and anthracite); Winter air conditioner with built-in stoker and bin-feed
Jefferson Electric Co., Bellwood, Ill.	227		
Jenkins Bros., New York, N. Y.	10		Valves
Johns-Manville, New York, N. Y.	800	H. R. Berlin, P. J. Washburn, C. W. Meyer, P. O. Young, R. E. Jones, Earl Hancock, P. W. Moninger, W. H. Wells, E. J. Sullivan, G. V. Dutney, L. C. Leslie, G. S. Nicely, J. M. Watt, J. S. Charles, J. Schmidt, M. J. Lennon, H. E. Nixon	Air Acoustic Sheets; Blown Rock Wool Home Insulation; Packings; Refractories; Industrial Insulations; Stack and Vent Pipe
Johnson Co., S. T., Philadelphia, Pa.	9-11	Robert P. Johnston, W. S. Harlacher, L. W. Kline, W. H. Rue	Steam and Hot Water Boiler-Burner Units; Hot Water Heaters; Winter Air Conditioning Units; Oil Burners
Johnson Service Co., Milwaukee, Wisc.	100	S. E. Plewes, R. A. Naegely, M. M. Herrick, N. E. Van Sickle	Automatic Temperature and Humidity Control for Heating, Cooling, Ventilating, Air Conditioning and Industrial Processing

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Keeney Publishing Co., Chicago, Ill	226		See American Artisan and Heating, Piping & Air Conditioning
Kehm Corp., Chicago, Ill.	440-442	H. J. Kehm, C. G. Newton, H. R. Coleman, E. Matthews, W. B. Gebbie	Complete Gas-Fired Forced Circulation Warm Water Heating System; Hot Water Heating Specialties; Forced Warm Air Ductless Gas-fired Heating System
Kent Company, Inc., Rome, N. Y.	825	C. E. Clifford, P. V. Hughes, Don Smith, Paul Young, E. P. Wittschiebe, R. Bauchmoyer, G. Blanchard, L. L. Steele	Double Suction Furnace and Boiler Cleaner
Kewanee Boiler Corp., Kewanee, Ill.	956-968	See American Radiator & Standard Sanitary Corp.	Residential Steel Boiler
Kleen-Heat Incorporated, Chicago, Ill.	865		
Korth Oil Burner Corp., Roselle Park, N. J.	531	Arnold Eckhart	Oil Burners
Lau Blower Co., Dayton, Ohio	619-621	E. B. Lau, R. A. Mayne, E. C. Wolford, Karl Ganger, Wm. Evans, Joseph Redrick, E. B. Berge, R. S. Wiseman.	Blower Assemblies, Blower Cabinets, Wheels, Pillow Blocks, Pulleys, Propeller Fans
Leslie Co., Lyndhurst, N. J.	235	Edwin Elliot, Edward J. Killgore, Joseph W. Pearson, Russell Boettiger, Frank Riggio	Pressure Reducing Valves, Pressure Controllers, Pump Governors, Temperature Regulators, Strainers
Linde Air Products Co., New York, N. Y.	432		Oxy-acetylene Blowpipes and Welding Equipment; Soldering Irons; Leak Detectors; Cylinders for Storing Refrigeration
McDonnell & Miller, Chicago, Ill	423	E. N. McDonnell, Jack McDonnell, Van A. Pfister, George La Roi, M. Blankin.	Boiler Feeders; Low Water Cut-Offs; Safety Relief Valves; Flow Switches; Snap Switches; Humidifier Valves; Pump Controls
McQuay, Inc., Minneapolis, Minn.	310-312-314		
Maid-O'-Mist, Inc., Chicago, Ill.	464	Wm. J. Woolley, O. V. Woolley, H. J. Carr, John H. Taylor, Ross W. Johnston	Automatic Humidifiers for all types of heating—Steam, Hot Water and Warm Air; Water Line Control Valves; Boiler Feeders and Low Water Cut-Offs; Automatic Air Vents for circulating lines, radiators, etc.
May Oil Burner Corp., Baltimore, Md	811-813-815-817	C. R. Collins, J. O. Miller, E. R. Schuelke, W. A. Webster, P. A. Wright	Conversion Burners; Boiler-Burner Units; Air Conditioning Units
Mercoid Corp., Chicago, Ill.	243-245-247	H. Courteol, I. E. McCabe, J. W. Owens, R. F. Fisher, W. Colterjohn, W. K. Stauffer, C. J. Grube, F. W. Ayer, Burt Power	Complete Line of Automatic Controls
Metals & Controls Corp., General Plate Division, Attleboro, Mass.	623	J. A. Payette, P. G. Chace, H. S. Phillips, U. U. Savolainen, H. P. Andrews, R. Kolseth, T. Mabry, L. J. Most, J. U. Sicard, E. L. Willis	Contacts; Thermostatic Metal in Sheet, Strip, Finished Parts and Sub-assemblies; Laminated and Precious Metal Tubing and Solders
Miller Co., Meriden, Conn.	50	W. Debler, O. R. Perkins, R. Delancey, H. Y. Harrison, W. Sullivan	Oil Burners for Small Homes
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.	810-814 909-913		Automatic Temperature Controls
Modine Mfg Co., Racine, Wis	224	A. G. Dixon, O. E. Desmond, M. J. Druse, Wm. Kidd, B. Spieth	Unit Heaters: Convectors; Ventilation Heaters
Monarch Mfg. Works, Inc., Philadelphia, Pa.	647	T. W. Murphy, J. M. Carrol, E. B. Frame	Air conditioning nozzles, air washing nozzles, humidifying sprays, oil atomizing nozzles, oil burner air mixing equipment, oil burner pumps, oil and water strainers.
Morrison Products, Inc., Cleveland, Ohio	546		Blower wheels
Morrison Steel Products, Inc., Buffalo, N. Y.	30	Sam Neide	Tubular Winter Air Conditioners; Gas Burners
Motorstokor Division, Hershey Machine & Foundry Co., Manheim, Pa.	932	J. H. Simpson, H. F. Miller, A. T. Bertolette, C. H. Olandt, H. L. Siegmund, A. J. Ulrich, H. D. Merrill, J. F. Fisher	Automatic Coal Burners (Anthracite)
Mueller Brass Co., Port Huron, Mich.	534–547	E. M. Fitzgerald, W. J. Constable	Solder-type Fittings (cast bronze and wrought copper); Valves, Fittings and Accessories for Mechanical refrigeration
Nash Engineering Co., South Norwalk, Conn.	124–223	Irving C. Jennings, Edward A. Mead, George B. Wright, W. M. Thompson, John B. Wright, Fred W. Green, C. J. Lyons, R. R. Donnelly, D. F. Parker, C. H. Love, James Mewshaw, L. T. Burroughs, W. H. Lukens, Charles Saints, H. B. Hawkins, Arthur Winship, T. L. Johnson, R. H. Carpenter	A complete line of pumps for the heating industry, including return line vacuum heating pumps, condensation pumps and the vapor-turbine return line heating pump, which operates from the system steam, and requires no electric current. Also sump pumps
National Machine Works, Chicago, Ill.	748	E. C. McLean, Barney Olson, S. B. Gamble	Power Gas Burners for central heating plants, either steam, hot water, or warm air—residential, commercial and industrial.

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
National Radiator Co., Johnstown, Pa.	550	E. L. Redden	Hand-fired boiler for defense housing; Gas boiler for small houses; Miniature steel boiler, representative of type used in U.S.O. recreation buildings and other defense industrial plants, army, navy and air corps buildings; Boiler used in replacement of old boilers in the maintenance of buildings classified under O.P.M. P22 order
National Tube Co., Pittsburgh, Pa.	648–747	J. E. Fleming, D. E. Hutchison, T. E. Conklin	Pipe and Tubes in plain carbon and alloy for use in the heating and ventilating industry
Nesbitt, Inc., John J., Holmesburg, Philadelphia, Pa.	918–920	H. Berkley Hedges, W. J. Rothenbach, M. E. Dunlap, Jr.	Blast coil heating surface with dual steam distributing tubes; Blast coil cooling surface—cold water type; Unit ventilator for school room heating and ventilating
Niagara Blower Co., New York, N. Y.	925	Paul H. Schoepflin, W. L. Offenhamer, D. L. King, C. N. Deverall, M. H. Olstad, O. F. Gilliam	Fan Heaters and Fan Coolers; Spray Coolers; Condensers
Norge Heating & Conditioning Div., Borg-Warner Corp., Detroit, Mich.	27		
Olsen Mfg. Co., C. A., Elyria, Ohio	417–419–421	C. A. Olsen, E. P. Hayes, Almon Chapin, W. T. Lyons, C. A. Patrick	Gas Air Conditioning Unit; Oil Air Conditioning Unit; Coal Air Conditioning Unit; Gas Hi-Boy Air Conditioning Unit; Coal Gravity Furnace, Gas Gravity Furnace, Defense Housing Forced Air Furnace
Owens-Corning Fiberglas Corp., Toledo, Ohio	666–765–766	C. L. Rowley, L. E. Fisher, W. R. Sykes, Murray Owen, E. V. Dragics, J. S. Irvine, W. B. Dias, F. L. Myers, F. D. Allen, E. E. French, F. G. Baechle	Air Filters, Industrial Insulation, Building Insulation, Electrical Insulation, Eliminator Mats
Pacific Gas Radiators Co., Huntington Park, Calif.	125–129		
Pacific Lumber Co., Chicago, Ill.	722	Harry L. Quinn, Marvin L. Fergestad, John H. Klass	Wool Insulation made from California Redwood Bark
Packless Metal Products Corp., New Rochelle, N. Y.	334	Steve Guarnaschelli	Self-flaring Copper Tube Fittings; Seamless Helical Flexible Bronze Hose with Detachable Couplings in complete units; Sections of large inside-diameter Flexible Bronze Hose
Peerless Mfg. Corp., Inc., Louisville, Ky.	939–941	H. E. Thompson, Robt. Lyman	Vented Gas Circulators, Gas Floor Furnaces; Domestic Stokers and Controls
Penn Boiler & Burner Mfg. Corp., Lancaster, Pa.	37–39		Boiler-Burner Units; Split System Hot Air Units
Penn Electric Switch Co., Goshen, Ind.	449	Albert Penn, M. E. Henning, R. H. Luscombe, K. W. Cash, Paul Penn, Robert Roepke, A. L. Rubel, M. Parcaro, J. E. Corbett, E. M. Smith, A. W. Barr, N. E. Jennison, J. R. Netedu	Heating and Air Conditioning Automatic Controls
Pennsylvania Furnace & Iron Co., Warren, Pa.	724		
Perfection Stove Co., Cleveland, Ohio	950–952–954		
Perolin Company of New York, Inc., New York, N. Y.	133–135	M. A. Solmssen, B. V. Tiblin, F. L. Burns, P. J. Goodman, S. Weiss	Fuel Oil Treatment
Petroleum Heat and Power Co., Stamford, Conn.	265–266	C. E. Shields, A. E. Hess, R. S. Thoresen, L. R. Babcock, E. F. Groves, L. E. Hodge, J. F. Corrigan	Industrial oil burning equipment
Philadelphia Electric Co., Philadelphia, Pa.	821		
Plumbing & Heating Journal, New York, N. Y.	742		Publication
Propellair, Inc., Springfield, Ohio	219–221		
Quaker Mfg. Co., Chicago, Ill.	47	Sam Johnson, L. J. Lofgren, O. J. Long, Jack Mathis, A. T. Atwill, O. B. Nelson, A. C. Roy	Oil Burning Furnaces; Conversion Burners
Randall Graphite Products Corp., Chicago, Ill.	143–147	R. H. Whiteley, E. A. Lampe, M. E. Clark, G. G. Terris at Benjamin Franklin Hotel	Pillow Blocks; Graphited Bronze Bearings
Refrigerating Engineering, New York, N. Y.	929		Publication
Reif-Rexoil, Inc., Buffalo, N. Y.	225		
Republic Steel Corp., Cleveland, Ohio	117–119–121–123		Steel Products
Reznor Manufacturing Co., Mercer, Pa.	637	David R. Webster, Morris G. Endres, George W. Reznor, Jack Peters	Gas fired suspended unit heaters.

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Rhoads & Sons, J. E., Philadelphia, Pa.	915–917	J. Edgar Rhoads, Richard H. Rhoads, Samuel L. Allen, Carl D. Wright, Harry H. Conrad, Walter B. Conover, Frank F. MacMurtrie, William A. Garrison	Transmission Drives; Flat Leather Belting
Ric-wiL Co., Cleveland, Ohio	341–339	C. Gottwald, M. A. Hanna, F. C. Belser, Geo. O'Connor, Val Cotman	Conduit systems for underground heating lines; Waterproof asbestos insulation
Ridge Tool Co., Elyria, Ohio	137–139–141	W. L. Parcell, C. O. Hollen, W. W. Graw, A. E. Armstrong	Pipe Wrenches; Pipe Threaders, Pipe Cutters; Pipe Vises; Tubing Cutters; Screw and Pipe Extractors
Rome-Turney Radiator Co., Rome, New York	536–538	William L. Lynch, John J. Boylan, E. L. A. Forster, E. J. Parry, J. M. Shannon, W. J. Beasley	Steam and Hot Water Heating Equipment; Condensers; Convectors; Cooling Equipment (Air); Evaporators; Heat Exchangers; Air Heaters; Copper Concealed Radiation; Radiator Enclosures and Shields; Refrigeration Receivers; Refrigeration Condensers; Tubing (finned)
Ruberoid Co., New York, N. Y.	539–541	J. M. High	Asbestos and Magnesia Pipe Coverings; Asbestos Paper; Asbestos Rollboard, etc.
Russell Co., F. C., Cleveland, Ohio	764	F. C. Russell, J. J. Morgenstern, A. S. Barker	Triple Service Windows; All Metal Venetian Awnings and Jalousies
Russell & Co., W. A., Bridgeport, Conn.	847	L. E. Pelletier, S. W. Mears, O. E. Tarbox, Fred Gander, R. W. Johnson	Air and Vacuum Valves; Humidifiers
Sampsell Time Control, Inc., Spring Valley, Ill.	134		
Sarco Co., Inc., New York, N. Y.	625–627	F. C. Perkins, E. J. Ritchie, R. W. Cumming, G. A. Binz, E. M. Donohue, P. Austin	Complete line of heating specialties for two pipe steam, vapor and vacuum systems; complete line of industrial steam traps; self-operated temperature regulators for water heating, air conditioning and refrigeration service; electric controls for heating and air conditioning; mixing valves for hot and cold water and steam and water; pipe line strainers
Schwitzer-Cummins Co., Indianapolis, Ind.	940	Walter Sormane, Robert Gruen, Harry Glou, H. J. Wilson	Anthracite and bituminous stokers, hopper and bin feed models; stoker-fired hot water heaters; Home ventilators; Blowers
Scott-Newcomb, Inc., St. Louis, Mo.	64		
Scully Steel Products Corp., Chicago, Ill.	648–747	W. P. Maguire	See U. S. Steel Corp.
Sheet Metal Worker, New York, N. Y.	809		Publication
Skuttle Sales Co., Detroit, Mich.	830		Humidifiers
Smith Co., Inc., H. B., Westfield, Mass.	320–322	Frank C. Hibbs, Richard Turner, Henry Madden, Walter Setzer	Cast Iron Boilers
Smith Twin Tubular Boiler Co., Inc., Tacony, Philadelphia, Pa.	615–617	Howard G. Smith, C. E. Woolston, Walter R. Dome.	Low Pressure Steel Heating Boilers
Spang Chalfant, Inc., Pittsburgh, Pa.	445	H. J. Kleinman, M. B. Squires, R. M. Syivis	Pipe
Spencer Heater Division, Aviation Mfg. Corp., Williamsport, Pa.	26		
Spencer Thermostat Co., Attleboro, Mass.	623	V. G. Vaughan, E. F. Kurtz, A. P. White, J. Ottmar, F. H. Appleton, J. A. Bagnall, M. T. Ball, J. N. Derby, R. M. Glidden, E. P. Jastram, N. A. Naylor, J. D. Bolesky, L. Wood Buell, H. M. Wilson, J. O. Moorhead	Thermostats, heating and air-conditioning controls, built-in overload protective devices for motors, transformers, solenoids and other electrical energy translating devices, relief valves for hot-water storage tanks, and miscellaneous other thermostatic devices.
Steel & Tubes Division, Republic Steel Corp., Cleveland, Ohio	117–119–121–123		
Sundstrand Machine Tool Co., Rockford, Ill.	826	C. H. Rystrom, W. A. Kemp, B. F. Olson, H. Wahlmark, H. Ekstrom	Fuel Units for Oil Burners
Surface Combustion Corp., Toledo, Ohio	725		
Taco Heaters, Inc., New York, N. Y.	210	J. R. Murphy, John H. White, H. A. Essley	Venturi Heating System
Thornburgh Mfg. Co., Cicero, Ill.	49		
Timken Silent Automatic Division—The Timken-Detroit Axle Co., Detroit, Mich.	409–411–413–415	T. A. Crawford, M. A. Powers, R. M. Marberry, W. J. Chappell, L. H. Holman, J. A. Hogan, W. F. Bolster, Carl Watres, W. W. Smith.	Oil Burners; Water Heaters; Defense Home Heating Units; Air Conditioning Oilfurnaces
Torrington Manufacturing Co., Torrington, Conn.	816–818	Alexis Doster, A. W. Evans, H. M. Risedorf, R. T. Lyman, D. G. Sullivan	Fan Blades; Blower Wheels
Trerice Co., H. O., Detroit, Mich.	215	J. L. Brackett, E. L. Myers, Robert Arnold, Ralph Dome	Thermometers, Temperature Controls, Steam Traps, Compressed Air Filters
Tuthill Pump Co., Chicago, Ill.	309	G. B. Tuthill, A. G. Hann. W. J. Wagner, N. Frederick	Section samples of pumps for Hydraulic Lubrication, Fuel Transfer, Oil Burners, Water Coolants, Noncorrosive Liquids

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
U. S. Air Conditioning Corp., Minneapolis, Minn.	219–221	F. D. Crew, B. P. Edelman, A. A. Horwitz, J. J. Ferretti, L. P. Hanson	Centrifugal Blowers; Light Duty Furnace Blowers; Coils, Cooling and Heating; Unit Heaters; Humidifiers
United States Radiator Corp., Detroit, Mich.	321–319	R. P. Henderson, Elwood S. White, W. E. Mosher, J. F. McIntire, J. R. Collette, K. W. Foster, D. E. Welsh	Cast Iron and Steel Boilers and Radiation; Warm Air Furnaces
United States Steel Corp., Pittsburgh, Pa.	648–747	See American Steel & Wire Co., Carnegie-Illinois Steel Corp., National Tube Co., Scully Steel Products Co.	Controlled-spangle galvanized sheets and other sheet products; power piping, heat exchanger and condenser tubes, ammonia pipe and other tubular products; wire and strip steel products
Viking Mfg. Corp., Cleveland, Ohio	57–59	H. S. Frasher, P. B. Patton, George J. Kaye, Wm. P. Loer, H. D. MacRae, C. W. Cape	Water Heaters; Oil Furnaces (vaporizing and gun type); Gas Furnaces
Waterfilm Boilers, Inc., Jersey City, N. J.	109	A. R. Hanson, E. Wodecka, J. Bainbridge	Tubular Boilers
Waterloo Register Co., Waterloo, Ia.	610–612	John C. Knox, I. M. Golan	*Marine Diffusers, Registers, Grilles and complete line of air control devices
Watts Regulator Co., Lawrence, Mass.	148		
Webster Electric Co., Racine, Wis.	250	S. A. Loeb, A. C. Kleckner, E. M. Ford, H. C. Osborne, L. F. McNeill, D. R. Parker, B. T. Wiechers	Fuel Units; Ignition Transformers
Webster & Co., Warren, Camden, N. J.	410–412–414–509–511–513	H. F. Marshall, B. F. Lerch, H. R. Betterton, C. G. Binder, L. H. Plum, W. H. Barron, H. N. Teuber, C. J. Kern, H. S. Ivins, D. F. Bennett, D. L. Higgins, W. C. Schuler, Karl Rugart, H. W. Doerrfuss, W. C. Ricord, C. H. Wells, Nelson H. Stewart	Steam Specialties; Steam Controls; Radiation; Expansion Joints; Unit Heaters
Weil-McLain Co., Chicago, Ill.	515–517–519	Thos. D. Casserly, Thos. Regan, A. M. Hopwood, C. A. Maxwell	Cast Iron Boilers and Cast Iron Radiators
Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.	400	B. M. Brown, Robert Munroe, J. B. Parke, P. H. Grunagle	Electro-static air cleaner; All purpose motor for oil burners, furnace blowers, ventilating fans and stokers
Westinghouse Electric & Mfg. Co., Springfield, Mass.	500	H. F. Hildreth, F. R. Reynolds, W. B. Cooper, W. C. Goodwin, L. Gale Huggins.	Air Conditioning; Water Coolers
White Mfg. Co., St. Paul, Minn.	113–115		
Wilson Co., H. A., Newark, N. J.	629	Judson Strong, A. D. Keedwell, E. A. Howard, L. Brock	Electrical Contact Materials; Thermostatic Bimetals; Clad Metals; Silver Clad Steel and Copper Clad Steel
Wing Mfg. Co., L. J., New York, N. Y.	311	Joseph Esherick, A. W. Ruwell	Unit heaters; Ventilating fans; Forced Draft Blowers
Wood Industries, Inc., Gar, Detroit, Mich.	336–338–340–342	F. H. Dewey, D. J. Luty, D. M. Kagay, George Hewitt	Oil-Fired Furnace-Burner Unit; Oil-Fired Boiler-Burner Unit; Gas-Fired Furnace-Burner Unit; Oil-Fired Water Heater; Prefabricated Fittings
Woolery Machine Co., Minneapolis, Minn.	732		
"X" Laboratories, Inc., New York, N. Y.	229	Parke Holton, F. W. Gibson, Jr.	"X" Liquid; "X" Flush Rustoff Treatment; "X" Pipecut Oil; "X" Pipe Joint Compound
Yale & Towne Mfg. Co., New York, N. Y. and Philadelphia, Pa.			
Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.	639	B. G. Waring, D. R. Yarnall, J. Kildare, A. L. Aicher, J. F. McKee, F. W. Miller, H. C. Woodward	Blow-off Valves; Water Columns and Gages; Steam Traps; Expansion Joints; Spray nozzles
York Ice Machinery Corp., York, Pa.	234–236–238–333–335–337	J. R. Hertzler, A. Winther, F. C. Wood, R. F. Muhleman, F. A. Weisenbach, M. S. Lebair, A. Christensen, R. F. Lauer, E. J. Berlet, Denton Fox, L. St. Onge, L. E. Kinley	6-cylinder Freon-12 Compressor; 8-cylinder Freon-12 Condensing Unit; New vertical air conditioner of the unitary type for connection with remote compressor; Vertical Gas Fired Air Conditioning Furnace; Oil Fired Air Conditioning Furnace; Self-Contained Air Conditioner; Portable Air Conditioner
Young Radiator Co., Racine, Wis.	822–824	M. F. May, R. M. Snow, W. A. Minkler, E. H. Stempel, F. C. Perkins	Air Conditioning Units; Unit Heaters; Convectors; Heating and Cooling Coils; Heat Exchangers
Young Regulator Co., Cleveland, Ohio	614	E. O. Young, J. H. Hucker, P. L. Pryibil	Regulators
Youngstown Sheet and Tube Co., Youngstown, O.	630–632	M. S. Curtis, G. W. Christopher, G. V. James, E. H. Hendricks, H. E. Richardson, P. G. Boyd, Wallace Badger, C. H. Longfield, H. H. Smith, W. E. Scott	Model of Continuous Butt-Weld Tube Mill

Heating·Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

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January, 1942

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War and Research

It is significant that there is hardly a single phase of production for war in which the work of the Society is not playing a prominent part. Not only have our members developed the ideas, the methods and the apparatus to accomplish these things, but many today are actively engaged in applying their knowledge either to design, supervision or construction of those elements of total war which are so essential to ultimate victory.

It is astonishing to find how the research work of the Society has influenced the development of the implements of war as well as means for the protection of the people. The research work of the past 20 years is crystallizing now and indicates what conditions of temperature and humidity are required for the maximum output of office workers, draftsmen and engineers, as well as the proper manufacture of wartime material under favorable conditions for the health of the workers. With blackout buildings called for throughout America, the requirements for ventilation are so important that the work on air conditioning requirements for industry is the basis of modern ventilation design.

Among the other contributions of utmost importance are fundamental work on fever therapy, on proper ventilating and air conditioning of operating rooms and convalescent wards, spot cooling for hot industries and for hot spaces in ships. Our field of endeavor embraces also design of low temperature chambers for determining reactions of flyers and divers in their enforced environment, proper heating and ventilating of barracks in cantonments and recommendations on the filtering and sterilization of air for the health of men in camp and in other occupied spaces.

Heating, ventilating and air conditioning engineers are doing invaluable work in speeding up production for total war and in providing protection for both the armed forces and the civilian population.

Walter L. Fleisher

January 1, 1942.

President, American Society of Heating and Ventilating Engineers

A Comparative Study of Friction-Heads in Screwed and Welded Elbows

By F. E. Giesecke* and J. S. Hopper**
College Station, Texas

This paper is the result of research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the Texas A. and M. College

SUMMARY—Ratios of the friction-heads in welded and screwed elbows are stated for three velocities and for three pipe sizes. Results indicate that the ratio of friction-heads for both welded and screwed elbows varies slightly with velocity of water and size of pipe.

During the study of friction-heads in 6 in. pipes and elbows,[1] reported in a previous paper, it was decided:

1. To adopt the *no-length* elbow concept in calculating the friction-heads in elbows.
2. To revise the friction-head charts for pipes and elbows in accordance with the results of the 6-in. pipe and elbow test, the results of the earlier tests of smaller pipes and elbows, and the *no-length* elbow concept.
3. To continue the study of the relative friction-heads in screwed and welded elbows.

No-Length Elbow

If, as shown in Figs. 2 and 6, the length of a pipe line is measured to and from the points of intersection of the center lines of the pipe line, a greater length is assigned to the pipe than actually exists and *no-length* remains to be assigned to the elbows.

If the results of friction-head tests in pipes and elbows are recorded and reported on this basis, a smaller friction-head is assigned to an elbow than would otherwise be the case, but the labor of calculating friction-heads in pipe lines is reduced materially because the lengths of the pipe lines are measured to and from the points of intersection of their center lines, as shown in Figs. 2 and 6.

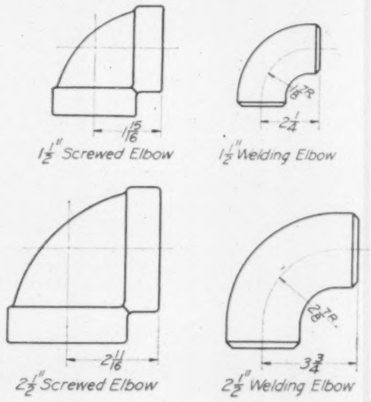
$1\frac{15}{16}$
$1\frac{1}{2}''$ Screwed Elbow
$1\frac{7}{8}$ R
$2\frac{1}{4}$
$1\frac{1}{2}''$ Welding Elbow
$2\frac{11}{16}$
$2\frac{1}{2}''$ Screwed Elbow
$2\frac{7}{8}$ R.
$3\frac{3}{4}$
$2\frac{1}{2}''$ Welding Elbow

Fig. 1—Four types of elbows tested

The revised friction charts for pipes and elbows are shown in Figs. 7 and 8 and need no detailed explanation. These charts are intended to be used in the design of pipe lines for hot water heating systems and not for the design of ordinary hydraulic installations. In hot water heating systems, properly operated, very little, if any, corrosion takes place because the same water is continually circulated through the system; for this reason, the charts of Figs. 7 and 8 have only a small allowance for the increase in friction resulting from corrosion that may take place during the life of the system.

In ordinary hydraulic installations the amount of corrosion varies with the material of which the pipe is constructed, and with the quality and quantity of water flowing through the pipe line. In such cases the amount of corrosion may be very material and larger friction factors must be used in the design of such installation than those shown in Figs. 7 and 8. During the study of the 6-in. pipe and elbow tests already referred to, it was found that the friction-heads in welded 6-in. elbows were considerably lower than those in screwed 6-in. elbows; for example, at velocities of 4, 5, and 6 fps, the friction-heads in the welded elbows were only 33, 37, and 40 per cent, respectively, or, on an average, 35 per cent of those in the screwed elbows.

Having found these ratios for 6-in. elbows, it was decided to determine the corresponding ratios for 2½-in. and 1½-in. elbows by laboratory tests, and the corresponding ratios for other sizes by interpolation and extrapolation, if the ratios determined experimentally for 6-in., 2½-in. and 1½-in. sizes should show a sufficiently definite relationship to permit that procedure.

The four types of elbows selected for this study are shown in Fig. 1. The experimental set-up for the 2½-in. elbow test is shown in Fig. 2. A portion of this set-up, when the 2½-in. welded elbow line was about to be removed and replaced by the 1½-in. screwed elbow line, is shown in Fig. 3.

The test procedure was the following. The water was circulated through the pipe line by a motor-driven pump; the flow of water in the pipe line was measured by means of a calibrated orifice-meter, located in a 10 ft section of 4-in. pipe; the friction-heads in the several sections of the pipe line were measured by the differences in the elevations of the water in vertical glass tubes, connected by pipe lines to the several piezometer rings shown in Fig. 2.

The pipe line section from PR_1 to PR_7 consisted of 82.67 ft of 2½-in. pipe and 6 screwed elbows; the section from PR_2 to PR_3 consisted of 47.84 ft of 2½-in. pipe and 6 screwed elbows. The difference between the two sections was 34.83 ft of 2½-in. pipe.

The results of the test of these two sections are shown in Table 1 and in Fig. 4, where the line AB ($h = 2.9V^{1.85}$) represents the friction-heads in the section from PR_1 to PR_7 and the line CD ($h = 1.87V^{1.91}$) represents the friction-heads in the section PR_2 to PR_3.

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*Professor Emeritus, Heating, Ventilating and Air Conditioning, A. and M. College of Texas. Member of ASHVE.

**Assistant Professor of Mechanical Engineering. A. and M. College of Texas. Member of ASHVE.

[1] Friction-Heads in Standard Six-Inch Pipe, by F. E. Giesecke and J. S. Hopper. (Journal Section, *Heating, Piping and Air Conditioning, February*, 1941.)

For presentation at the 48th Annual Meeting of the American Society of Heating and Ventilating Engineers, Philadelphia, Pa., January, 1942.

The differences between the friction-heads shown by line AB and those shown by line CD are the friction-heads in 34.83 ft of 2½-in. pipe.

Having thus determined the friction-head in 34.83 ft of pipe, it was planned to use it to determine the friction-head, first, in 1 ft of 2½-in. pipe, and second, in one 2½-in. elbow; before doing this, it was decided to check the results shown by lines AB and CD in Fig. 4 with those which should be expected according to the charts of Figs. 7 and 8, and it was found that for the higher velocities the measured friction-heads were higher than those calculated from the charts and for the lower velocities they were lower.

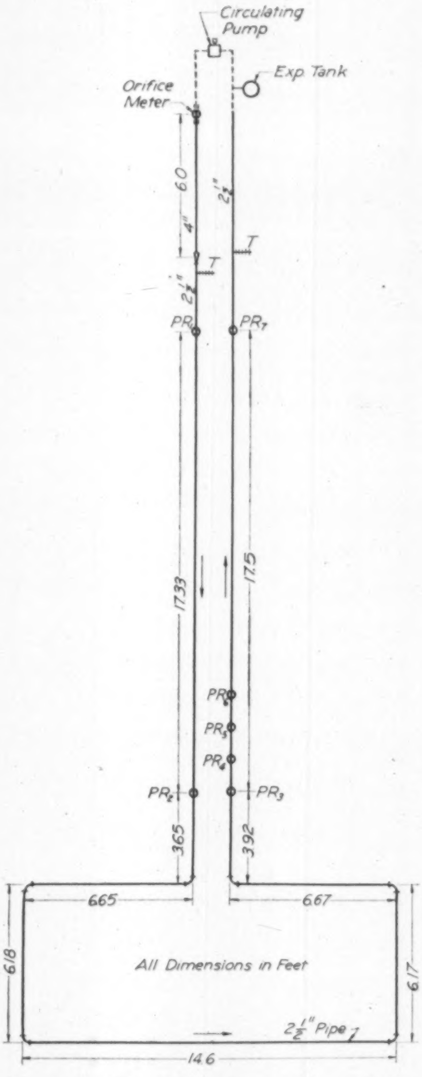

Fig. 2—Pipe line for testing 2½-in. elbows

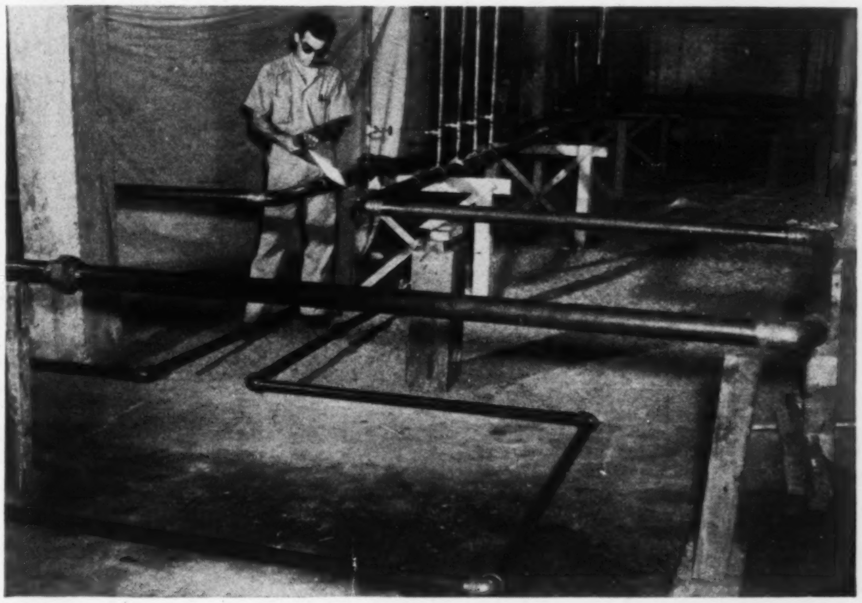

Fig. 3—Pipe line for testing 2½-in. elbows when about to be replaced by pipe line for testing 1½-in. elbows

According to the charts, the friction-heads in one ft of 2½-in. pipe and in one elbow, and for velocities of 4, 5, and 6 fps are respectively, 0.330, 0.480, 0.660, 1.900, 2.800, and 4.000 in.

A second check was then made by calculating the friction-heads in the two lines by the formulae[2] developed by the senior author for new and clean pipes, i.e.,

$$h = 0.00685 \frac{V^{1.79D-0.04}}{D^{1.275}} \text{ ft per foot of pipe}$$

and $h = 0.0141 \dfrac{V^{1.96}}{D^{0.26}}$ ft per elbow.

For 2½-in. pipe these formulas become $h = 0.0259_v{}^{1.73}$ in. per ft of pipe and $h = 0.138_v{}^{1.96}$ in. per elbow.

The three sets of friction-heads for the two pipe lines, from PR_1 to PR_7 and from PR_2 to PR_3, are shown in the following tabulations; the three sets for the line from PR_1 to PR_7 are also shown in Fig. 4.

VELOCITY—FEET PER SECOND

	4	5	6
Measured......	37.7	57.90	80.00
Chart.........	38.6	56.48	75.56
Formula.......	36.1	54.08	75.32

Friction Heads for pipe line from PR_1 to PR_7.

Measured......	26.4	40.4	57.3
Chart.........	27.18	39.76	55.57
Formula.......	26.17	39.48	55.29

Friction Heads for pipe line from PR_2 to PR_3.

It appears from these tabulations that the values derived from the chart agree well with those calculated according to the original formula; the values from the chart being slightly higher to allow for the effect of slight corrosion.

It also appears that the values secured by direct measurement do not agree with those derived from the chart. The cause for this disagreement is evidently that the jet of water which emerges from the orifice-meter into the 2½-in. pipe line with a high velocity creates additional turbulence which extends far into the pipe line and causes the additional friction-head.

The orifice is 1.75-in. in diameter and hence the velocities of the jet of water are respectively 8, 10, and 12 fps when the velocities of the water in the 2½-in. pipe are 4, 5, and 6 fps.

It has been known for some time that the additional turbulence produced within an elbow extends for a considerable distance into the down-stream pipe line and increases the friction-head within that pipe line, but this is the first time the authors have experienced the disturbing effect of a stream of water projected into a pipe line.

It is evident from this study that the two lines, AB and CD of Fig. 4, should not be used to determine the friction-head in one screwed elbow for comparison with that of one welded elbow, but that this friction-

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[2] University of Texas, *Bulletin No.* 1759.

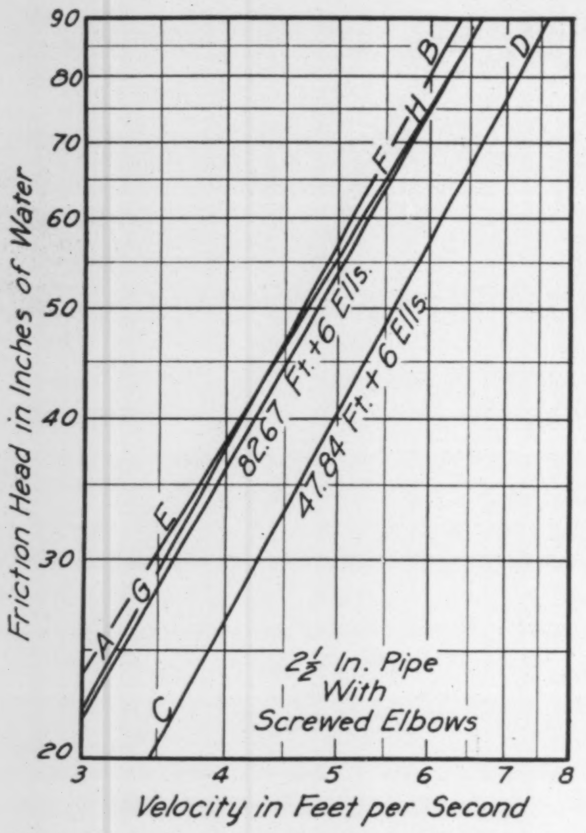

Fig. 4—Friction-heads in sections PR_1 to PR_7 and in Sections PR_2 to PR_3 of 2½-in. pipe line

The line *AB* was determined by experiment during this investigation. The line *EF* was calculated according to the values shown in the charts for Figs. 7 and 8. The line *GH* was calculated according to formulae determined in earlier studies.

Since the line *AB* is steeper than the lines *EF* and *GH*, there seems to be a disturbing element in the experimental set-up which increases the friction-head in the 2½-in. pipe. This disturbing element may be the jet of water projected from the orifice meter into the pipe. When the velocity of the water in the 2½-in. pipe is 3 fps, the velocity of the jet is 5.98 fps; and when the velocity of the water in the 2½-in. pipe is 6 fps, the velocity of the jet is 11.95 fps. The influence of the jet must therefore increase with the velocity of the water and must tend to increase the slope of the line *AB* which represents the friction-heads in the 2½-in., pipe of the experimental set-up.

Table 1—Test of 2½-In. Screwed Elbows
(*July* 11 *and* 14)

METER READING INCHES	VELOCITY FEET PER SECOND	WATER TEMPERATURE FAHRENHEIT	FRICTION-HEAD SECTION 1-7 INCHES	FRICTION-HEAD SECTION 2-3 INCHES
1	2.60	84	15.0	11.0
1	2.60	85	17.0	11.8
1	2.60	90	16.0	10.5
1	2.60	91	14.5	10.5
Average		87.5	15.6	11.0
2	3.56	85	31.0	22.0
2	3.56	85	30.5	20.5
2	3.56	89	29.3	20.8
2	3.56	90	30.3	22.0
Average		87.3	30.3	21.3
3	4.41	86	44.0	31.5
3	4.41	86	45.0	32.0
3	4.41	89	43.3	31.0
3	4.41	90	43.5	31.0
Average		87.8	44.0	31.4
4	5.06	87	58.5	41.5
4	5.06	87	58.0	40.8
4	5.06	88	57.0	40.3
4	5.06	89	57.5	40.5
Average		87.8	57.8	40.8
5	5.70	87	72.3	50.8
5	5.70	88	71.5	50.5
Average		87.5	71.9	50.7

Section 1-7 consisted of 82.67 ft of 2½-in. pipe, 1 union, and 6 elbows.
Section 2-3 consisted of 47.84 ft of 2½-in. pipe, 1 union, and 6 elbows.

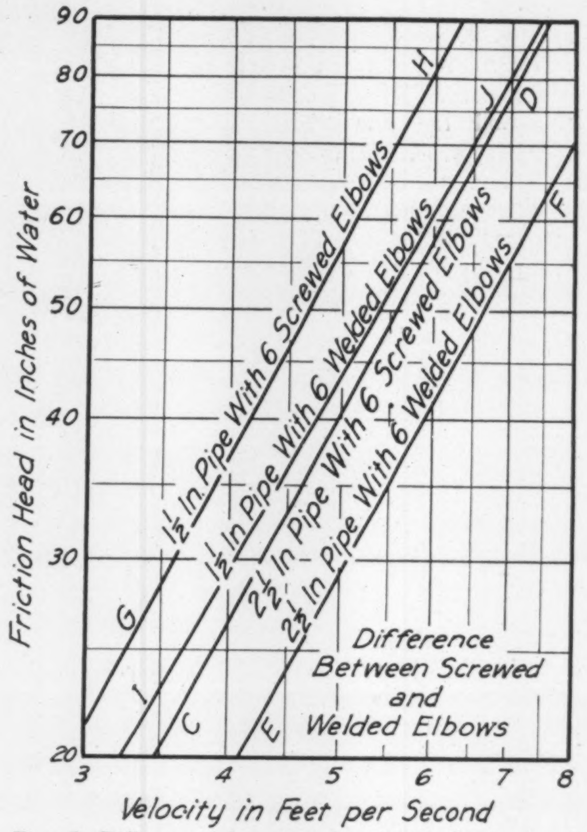

Fig. 5—Differences between the friction-heads in 6 screwed and in 6 welded elbows for 1½-in. and 2½-in. pipe

The average slope of the two 2½-in. lines, *CD* and *EF*, is greater than was expected in comparison with the average slope of the two 1½-in. lines, *GH* and *IJ*. This may be the result of the influence of the jet of water which was projected from the orifice meter into the pipe lines, since, for any one velocity of the two pipe lines, the velocity of the jet is greater for the 2½-in. line than for the 1½-in. line. For example, for a velocity of 5 fps in the pipe lines, the velocity of the jet is 9.96 fps for the 2½-in. line and 4.23 fps for the 1½-in. line.

The two 2½-in. lines diverge less than the two 1½-in. lines. This may also be the result of the influence of the jet of water from the orifice meter on the friction-heads in the two pipe lines.

Studies are in progress to determine the influence of a jet of water on the friction-head in a pipe line into which the jet is projected.

Table 2—Test of 2½-In. Welded Elbows
(*July* 24 *and* 28)

METER READING INCHES	VELOCITY FEET PER HOUR	WATER TEMPERATURE FAHRENHEIT	FRICTION-HEAD SECTION 1-7 INCHES	FRICTION-HEAD SECTION 2-3 INCHES
1	2.60	87	13.50	8.75
1	2.60	88	13.00	8.50
1	2.60	93	12.00	8.00
1	2.60	93	12.25	8.00
Average		90.3	12.69	8.31
2	3.56	88	23.75	15.00
2	3.56	89	25.25	16.50
2	3.56	93	24.00	15.00
2	3.56	93	23.75	15.50
Average		90.8	24.19	15.50
3	4.41	89	35.50	22.50
3	4.41	89	34.50	22.50
3	4.41	92	35.25	22.75
3	4.41	92	35.00	23.00
Average		90.5	35.06	22.69
4	5.06	89	46.00	29.50
4	5.06	90	46.00	30.00
4	5.06	91	45.75	29.50
4	5.06	91	45.50	29.00
Average		90.3	45.81	29.50
5	5.70	90	55.00	35.50
5	5.70	91	56.50	36.00
Average		90.5	55.75	35.75

Section 1-7 consisted of 82.58 ft of 2½-in. pipe, 1 union, and 6 elbows.
Section 2-3 consisted of 47.75 ft of 2½-in. pipe, 1 union, and 6 elbows.

Table 3—Test of 1½-In. Screwed Elbows
(*August* 7 *and* 16)

TIME SECONDS	WATER POUNDS	VELOCITY FEET PER SECOND	TEMPERATURE FAHRENHEIT	FRICTION-HEAD SECTION 2-3 INCHES
300	500	1.89	88	9.00
60	100	1.91	86	9.25
59	100	1.93	86	9.25
290	500	1.96	88	9.37
39	100	2.97	86	20.75
38	100	2.97	86	20.50
183	500	3.10	88	22.75
178	500	3.19	88	24.00
30	100	3.79	86	33.00
30	100	3.82	86	33.50
134	500	4.25	88	41.50
26	100	4.35	86	43.00
26	100	4.35	86	42.90
130	500	4.37	88	44.00
109	500	5.19	88	60.00
22	100	5.20	86	58.00

Section 2-3 consisted of 3.54 ft of 2½-in. pipe, 2 reducers with face bushings, 43.51 ft of 1½-in. pipe, 3 unions, and 6 elbows.

Table 4—Test of 1½-In. Welded Elbows
(*August* 22 *and* 27)

TIME SECONDS	WATER POUNDS	VELOCITY FEET PER SECOND	TEMPERATURE FAHRENHEIT	FRICTION-HEAD SECTION 2-3 INCHES
273	500	2.08	93	8.87
262	500	2.17	91	9.75
250	500	2.26	93	10.50
249	500	2.28	91	10.50
164	500	3.48	91	23.00
154	500	3.68	91	25.50
154	500	3.68	93	25.00
151	500	3.77	93	26.25
133	500	4.26	93	45.13
123	500	4.50	91	39.00
122	500	4.65	91	39.38
121	500	4.72	93	40.00
120	500	4.75	93	40.13
104	500	5.48	91	53.63
101	500	5.62	93	55.12

Section 2-3 consisted of 3.54 ft of 2½-in. pipe, 2 reducers with face bushings, 43.32 ft of 1½-in. pipe, 3 unions, and 6 elbows.

head should be calculated by the formula $h = 0.138v^{1.96}$.

After the pipe line with the 6 screwed elbows, shown in Fig. 2, had been tested, the screwed elbows were removed and replaced by 6 welding elbows in such a manner that the total length of the pipe line remained practically unchanged. The length of the section from PR_2 to PR_3 with screwed elbows was 47.84 ft and with welded elbows, 47.75 ft. The test was then performed with the welded elbows as it had been for the screwed elbows. The results for the section from PR_2 to PR_3 are shown in Table 2 and by line *EF* in Fig. 5. Line *CD* of Fig. 5 is the same as line *CD* of Fig. 4. The difference between the friction-heads shown by line *CD* and those shown by line *EF* are the differences between the friction-heads in 6 *no-length* screwed and 6 *no-length* welded 2½-in. elbows.

The friction-head in one *no-length* welded 2½-in. elbow was then calculated as illustrated in the following tabulation:

PIPE LINE SECTION	VELOCITY—FEET PER SECOND		
	4	5	6
PR_2 to PR_3 ($h=1.87\,V^{1.91}$) Line *CD*, Fig. 5.	26.4	40.4	57.3
PR_2 to PR_3 ($h=1.39\,V^{1.89}$) Line *EF*, Fig. 5.	19.1	29.1	41.1
Difference between 6 screwed and 6 welded elbows	7.3	11.3	16.2
Difference between 1 screwed and 1 welded elbow	1.21	1.88	2.70
One screwed elbow ($0.138V^{1.96}$)	2.09	3.24	4.63
One welded elbow	0.88	1.36	1.93
Ratio	42%	42%	42%

To study the friction-heads in 1½-in. elbows, the 1½-in. pipe line was attached to the 2½-in. pipe line used in the previous test, as shown in Fig. 6; the two pipe lines were joined by 2½ x 2 reducers and 2 x 1½ face bushings.

The pipe line section from PR_2 to PR_3 consisted of 3.54 ft of 2½-in. pipe, 2 reducers with face bushings, 43.51 ft of 1½-in. pipe, and 6 screwed 1½-in. elbows.

It was found that the orifice-meter, used in the previous test, could not be read with sufficient accuracy for the small flow needed for the 1½-in. line, so the pipe set-up was changed and the rate of flow through the 1½-in. pipe line determined by weighing the water; otherwise the test was performed in the same manner as that for the 2½-in. pipe. The length of the 1½-in. pipe line with screwed elbows was 43.51 ft with 6 elbows.

The results of this test are shown in Table 3 and by line *GH* of Fig. 5.

The screwed elbows were then removed and replaced by welded elbows in such a manner that the length of the pipe line remained practically unchanged. The test was then performed as before; the results are shown in Table 4 and by line *IJ* of Fig. 5.

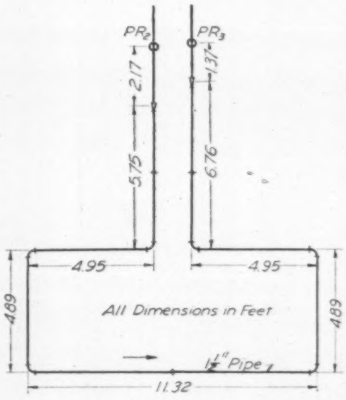

Fig. 6—Pipe line for testing 1½-in. elbows

The friction-heads in one *no-length* welded 1½-in. elbow were then calculated as illustrated in the following tabulation:

PIPE LINE SECTION	VELOCITY FEET PER SECOND		
	4	5	6
PR_2 to PR_3 ($h = 2.57\,V^{1.93}$)	37.3	57.4	81.6
PR_2 to PR_3 ($h = 2.46\,V^{1.79}$)	29.4	43.9	60.8
Difference between 6 screwed and 6 welded elbows	7.9	13.5	20.8
Difference between 1 screwed and 1 welded elbow	1.31	2.25	3.47
One screwed elbow ($0.149\,V^{1.96}$)	2.26	3.50	5.01
One welded elbow	0.95	1.25	1.54
Ratio	42%	36%	31%

Summary

The ratios of the friction-heads in *no-length* welded elbows to those in *no-length* screwed elbows, for the three velocities listed and for the three pipe sizes tested, are shown in the following tabulation.

PIPE SIZE	VELOCITY IN FEET PER SECOND		
	4	5	6
6-in.	0.33	0.37	0.40
2½-in.	0.42	0.42	0.42
1½-in.	0.42	0.36	0.31

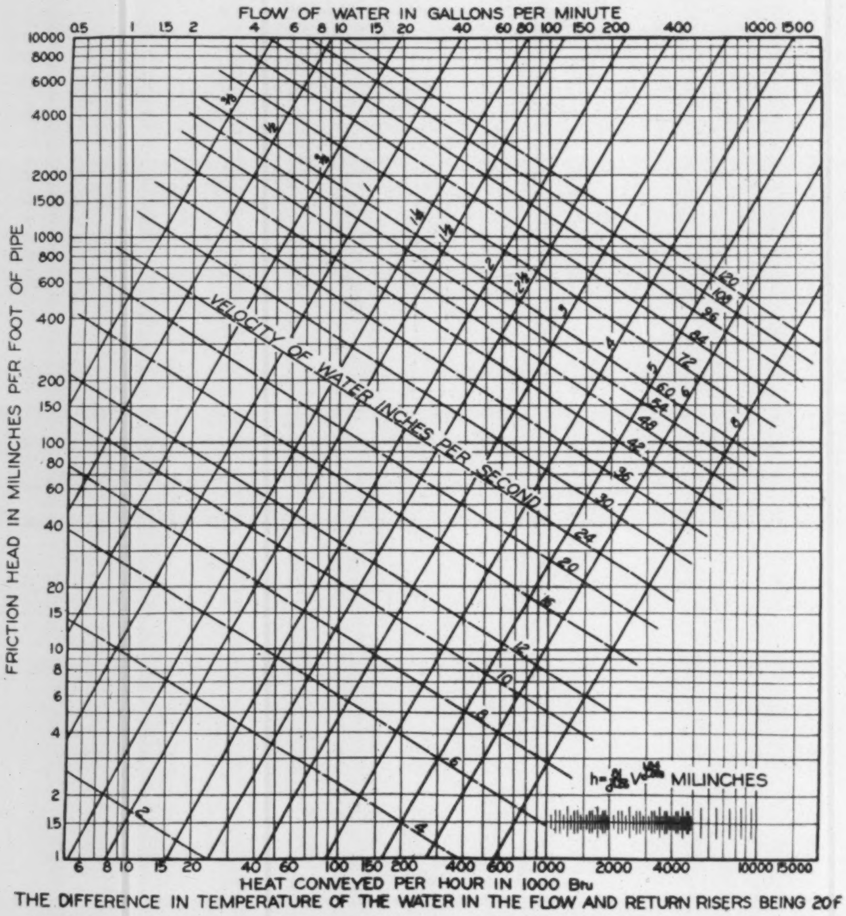

Fig. 7—Friction-heads in standard black pipe

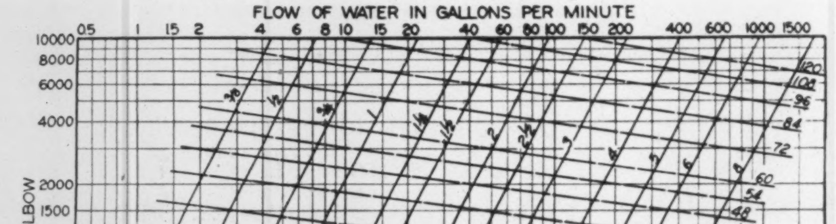

Fig. 8—Friction-heads in no-length black elbows (standard)

These results are not as consistent as had been expected before the investigation was begun. The variations in the results may be attributable to the fact that the three sets of elbows were tested by three different methods. For the 6-in. size, the results are based entirely on the experimental determinations. For the other two sizes, the ratios are based on the friction-heads in new and clean screwed elbows as determined in earlier investigations. In the 1½-in. tests, the velocity of the water was determined by weighing the water flowing through the line; in the other two tests, the velocities were determined by means of orifice-meters.

However, it is possible with the *no-length* elbow concept, that the ratio may be independent of the velocity for the 2½-in. size; that it increases as the velocity increases, with the larger sizes; and that it decreases as the velocity increases, with the smaller sizes, as indicated by the results of this investigation.

Conclusion

As the final result of this study it appears that the ratio of the friction-heads in *no-length* welded and *no-length* screwed elbows varies only slightly with the velocity of the water and also only slightly with the size of the pipe.

Until additional experimental data shall have been secured, it may be well to base friction-head calculations on the friction-heads in screwed elbows and to reduce the results to one-half, or slightly less, for welded elbows of corresponding sizes.

Acknowledgment

The authors take pleasure in acknowledging their obligation for valuable assistance in this study to L. P. Thompson, M.S., Instructor in Mechanical Engineering; B. R. Holland, M.S., Instructor in Chemistry; J. G. McGuire, M.S., Professor of Drawing; and H. P. Rigsby, Instructor in Welding. Mr. Thompson made practically all calculations; Mr. Thompson and Mr. Holland performed the major portion of the laboratory work; Professor McGuire prepared a majority of the drawings; and Mr. Rigsby did the welding.

The Performance of Stack Heads Equipped with Grilles

By D. W. Nelson,* D. H. Lamb** and G. E. Smedberg***
Madison, Wis.

This paper is the result of research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with University of Wisconsin

Introduction

THE present report concerns the influence of grilles when placed on the stack openings. A previous paper[1] reported the results with plain openings; that is, without grilles. The same test setup as used in the previous tests was used in the present series, and is shown in Fig. 1. The apparatus consists mainly of a fan, a long 12 in. duct in which a 5 in. rounded approach nozzle was located, and a plenum chamber on which a 14 in. x 6 in. stack 8 ft high was placed.

Procedure

The same gages and instruments were used with the exception that an improved directional indicator as shown in Fig. 2 was made and found to be more convenient. With each stack head and grille combination, observations were made of the direction and velocity at the center of each of nine equal areas of the face, the direction at the four sides of the air stream 12 in. out from the face, the distance from the bottom edge of the face up to the location at which reversed flow began, the static pressure at the base of the stack head and the pressure readings at the flow nozzle for volumetric determinations. Previous to each test calculations were made to determine the proper gage settings for velocities in the stack of 200, 500, 800, 1100 and 1400 fpm. These speeds correspond to a Reynolds' number based on the stack area of 14,400, 36,000, 57,500, 79,100, and 100,600, respectively.

SUMMARY — Grilles having high resistance were found to give more uniform flow from a stack head than those having low resistance. The angle of discharge from stack heads with various grilles is not influenced by stack velocity, but is affected by the type of stack head and grille. Negative angles of discharge were obtained with grilles having low free areas. With decrease in net face area of grilles the static pressure increased slowly while the negative flow area is decreasing

The grilles used were of diverse patterns, as shown in Fig. 3, and were chosen for having considerable influence on the air stream. A description of the grilles and the free areas when used with each of the stack heads Nos. 4, 5, and 6 is given in Fig. 4. This figure also shows the dimensions for these three square throated stack heads.

The direction of air flow in each case was from right to left of the grille section, as shown in Fig. 4. The grilles listed as No. *7B* and *7D* were grille No. 7, used as shown in the upper and lower section, respectively, for this grille, and grille No. *7A* and *7C* for the air flow in the same direction, but with the grille inverted to direct the air upward.

Table 1 lists the symbols used to designate the various stack head and grille combinations on the curves of Figs. 8, 9, 10, and 17.

Discussion of Results

Discussion of the performance of the various stack heads with grilles will first consider velocities and negative flow areas, then directional effects, and finally static pressures at the base of the stack head.

Velocities and Negative Flow Areas

Without a grille, the tendency is for the highest velocity to be in the upper third of the stack head face and for the reverse flow areas to be large, being largest with stack head No. 6 and smallest with stack head No. 4. In Figs. 5, 6, and 7, the velocities and directions of the air streams are shown for stack velocities of 500 and 1100 fpm for stack heads Nos. 4, 5, and 6, respectively. In these figures the variations in velocity and in the area of negative flow are shown graphically. Without a grille, stack head No. 6 with a 14 in. x 12 in. opening has a reverse flow area which occupies the entire lower half of the face. With high average velocities and grilles of low free area, the velocity in the top third of the face is slightly lower than the average velocity, while with grilles of high free area the velocity

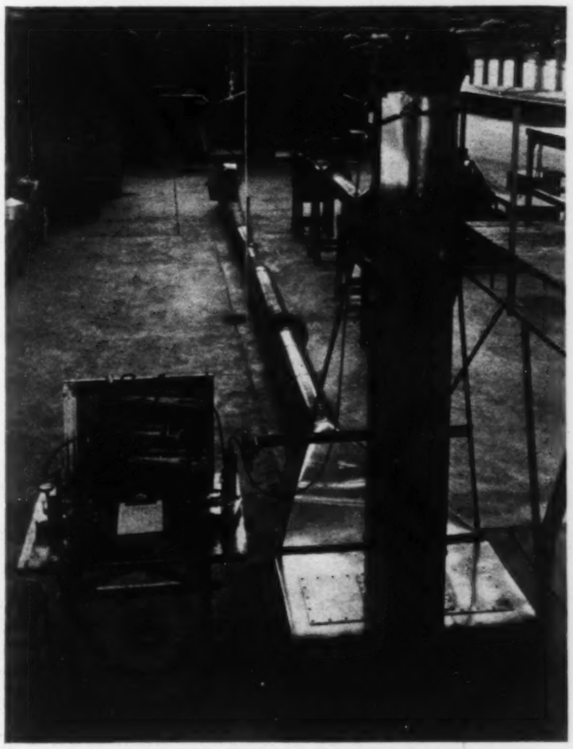

Fig. 1—View of apparatus

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*Associate Professor of Mechanical Engineering, University of Wisconsin. MEMBER of ASHVE.

**Formerly Research Assistant, University of Wisconsin, 1940-41.

***Research Fellow, University of Wisconsin, 1940-42.

[1] The Performance of Stack Heads, by D. W. Nelson, D. H. Krans and A. F. Tuthill. (ASHVE TRANSACTIONS, Vol. 46, 1940.)

For presentation at the 48th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1942.

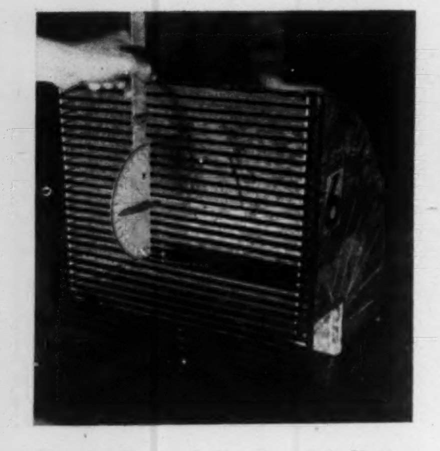


Fig. 2—View of directional indicator

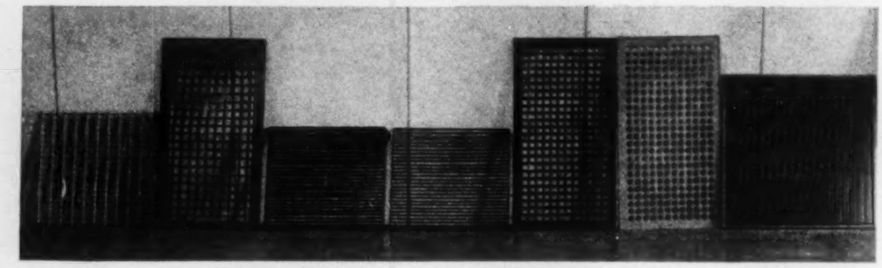


Fig. 3—Various types of grilles tested

in the top third is higher than the average velocity.

From Fig. 8, in which the negative flow area in per cent of stack head area is plotted against the per cent free area of the stack head, it is apparent that there will always be an area of negative flow unless the free area is reduced by either restricting the stack head outlet or by use of a high resistance grille such as Nos. 5 and 6. It will also be noted from this same figure that each of the stack heads have no negative area when a grille of 25 per cent free area is used. With a free area greater than this value, the negative area increases. This effect is most pronounced with stack head No. 6, and least pronounced with stack head No. 4. In Fig. 9, the net discharge area in per cent of stack head area is plotted against the per cent free area of the grille. It will be noted on Fig. 8 that for the stack heads tested, a grille with a free area of 25 per cent results in the spreading of the air over the complete face of the grille; that is, the complete removal of the negative flow area.

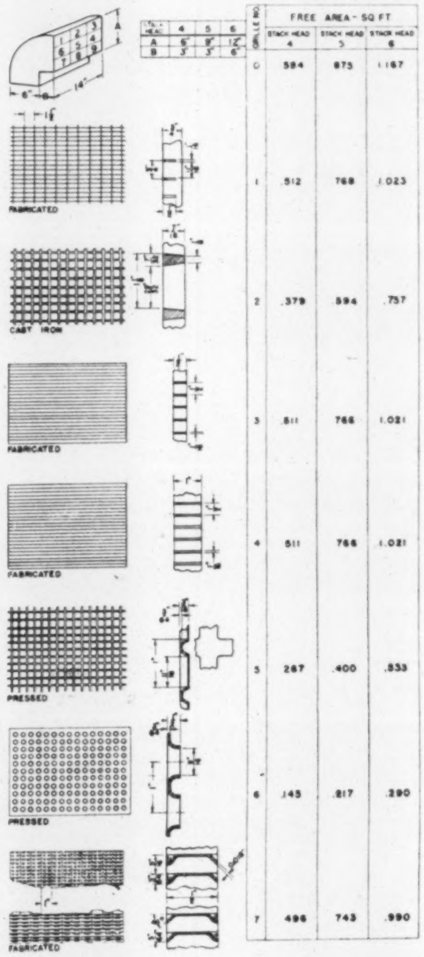
Table 1—Symbols Used on Curves for Stack Head and Grille Combinations

GRILLES	STACK HEADS		
	4	5	6
0	○	⦶	⊖
1	◇	◇⃒	◇̶
2	◁	◁⃒	◁̶
3	▷	▷⃒	▷̶
4	▽	▽⃒	▽̶
5	□	□⃒	□̶
6	△	△⃒	△̶
7A	◒	◒⃒	◒̶
7B	◓	◓⃒	◓̶
7C	◑	◑⃒	◑̶
7D	◐	◐⃒	◐̶

It will be seen from the flow patterns of Figs. 5, 6 and 7 that a grille of low free area, as grilles Nos. 5 and 6, results in a more uniform flow over the face than that obtained with one of large free area or one with no grille. However, the velocity is very high at the face due to the low free area, and there is little or no negative area at the bottom of the grille. With grille No. 7 having deflecting fins, no difference in negative flow area was found, whether the air was directed upward or downward, as shown in Figs. 5, 6, and 7. The several tests indicate that as the stack head height is increased, the per cent free area used decreases. This would approach zero per cent at an infinite stack height. Extension of such a curve toward zero stack head height indicates that with a face height of approximately 4.5 in. or smaller and a stack depth of 6 in., no negative flow area would occur. With the addition of grilles, discharge over the entire face area can be secured for stack heads with face heights of more than 4.5 in.; the less the free area, the greater will be the face height without negative flow. However, the net discharge area used has not been increased by this procedure. From this it appears that there is an optimum face height for each type of stack head with a certain stack depth in order that no negative flow will be present. Figs. 8 and 9 are related to this discussion.

Directional Effects

In Fig. 11 a graphical summary of the angles of discharge for the air stream in the upper third of the face opening is shown for various grille and stack head combinations at 500 and 1100 fpm stack velocities. From this figure and Tables 2, 3 and 4 it will be noted that at each combination of stack head and grille the velocity in the stack does not affect the angle of discharge appreciably. For example, the angle for the stack head No. 4 without a grille is approximately 7 deg up for all stack velocities used. This indicates that the velocity in the stack is not a major factor, and that the type of stack head, its dimen-



STK. HEAD	4	5	6
A	6"	9"	12"
B	3"	3"	6"

GRILLE NO.	FREE AREA - SQ FT		
	STACK HEAD 4	STACK HEAD 5	STACK HEAD 6
0	.584	.875	1.167
1	.512	.768	1.023
2	.379	.594	.757
3	.511	.766	1.021
4	.511	.766	1.021
5	.267	.400	.533
6	.145	.217	.290
7	.496	.743	.990

Fig. 4—Construction and free areas of grilles and stack heads tested

sions, and the type of grille used are the deciding factors as regards the angle of discharge. In general, the upward tilt of the air stream increases with face height. This angle is greatest for stack head No. 5, and least for stack head No. 4. For stack head No. 6, with the greatest face height, this trend does not hold closely due to the guiding effect of the greater face to throat dimension. The angle without grilles for stack head No. 6 was about 18 deg, as against 27 deg for No. 5 and 8 deg for No. 4. Fig. 11 shows the pronounced directional effect of grille No. 7 when it is turned four different ways. The stack heads without a grille and with grille Nos. *7A* and *7C* impart a definite upward direction to the air stream, grilles *7B* and *7D* give a downward direction, and grilles 5 and 6 also give a downward deflection, while the other grilles give a direction closer to horizontal. Even though stack head No. 5 without a grille has the highest angle of discharge, and the No. 4 the lowest in most every case, this is not true when these stack heads are used in combination with the highly directional grille No. 7, which gives nearly the same angle of discharge for all three heads.

In Fig. 10 the direction of the angle of flow is plotted against the per cent of free area of the stack head, and for all grilles except No. 7, which has directional construction. It will be noted that the lower the free area of the grille in per cent of the stack head area, the lower is the angle of discharge. The nondirectional grille No. 6 on stack head Nos. 4 and 6 resulted in a downward deflection of the air stream in the top third of the face opening of about 20 deg. Fig. 10 shows, in general, the greatest downward deflection for grilles on stack head

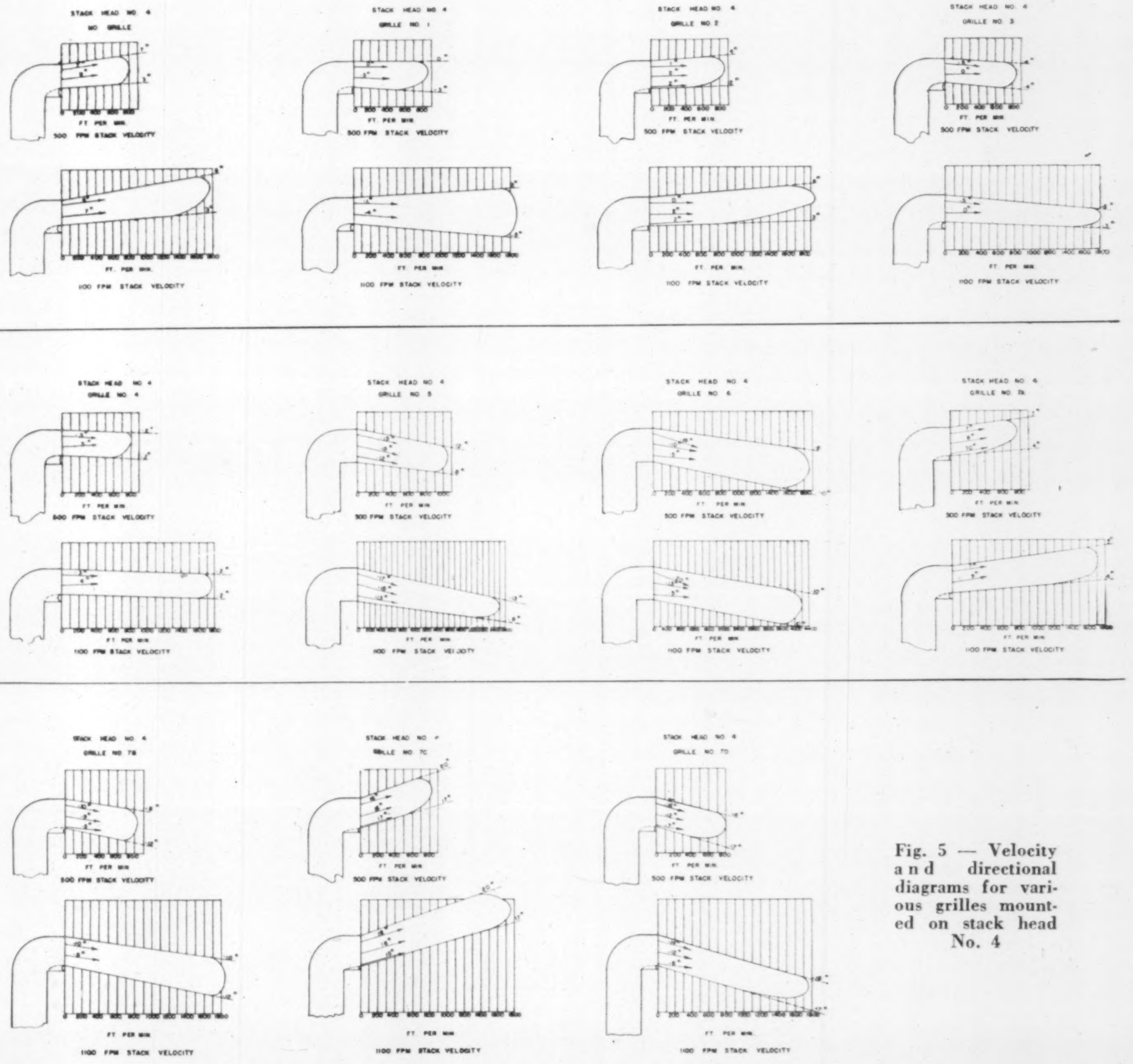


Fig. 5 — Velocity and directional diagrams for various grilles mounted on stack head No. 4

No. 4, intermediate deflections for stack head No. 6, and least deflection for No. 5. From inspection of Figs. 5, 6, 7, and 10, it will be noted that the high resistance grille Nos. 5 and 6 give a definite downward direction to the air stream. The one exception to this statement is with grille No. 5 on stack head No. 5, which lowers the angle from an upward 27 deg to an upward of 5 deg. This downward deflection seems to be caused by the crowding of the air to the top of the stack head as it makes the turn, and the effect of the high resistance grille in shutting off complete escape at the top of the face opening. Therefore, a considerable quantity of the air stream must escape through grille openings in the lower parts of the face, and the air takes a downward path from the upper part of the stack head to this location. It is therefore leaving the grille openings at a lower angle than when escaping through the unrestricted stack head without a grille or the less restricted face with a low resistance grille. This downward tilt is associated with low negative flow area as well as with high resistance of the face opening. In Figs. 12*a* and 12*b* are shown two photographs taken in an air flow analyzer which indicate this behavior. In Fig. 12*a*, a stack head somewhat similar to No. 6 is shown without a grille, and in which the crowding of the air stream at the top of the stack head is noticeable. In Fig. 12*b*, when the free area of a stack head somewhat similar

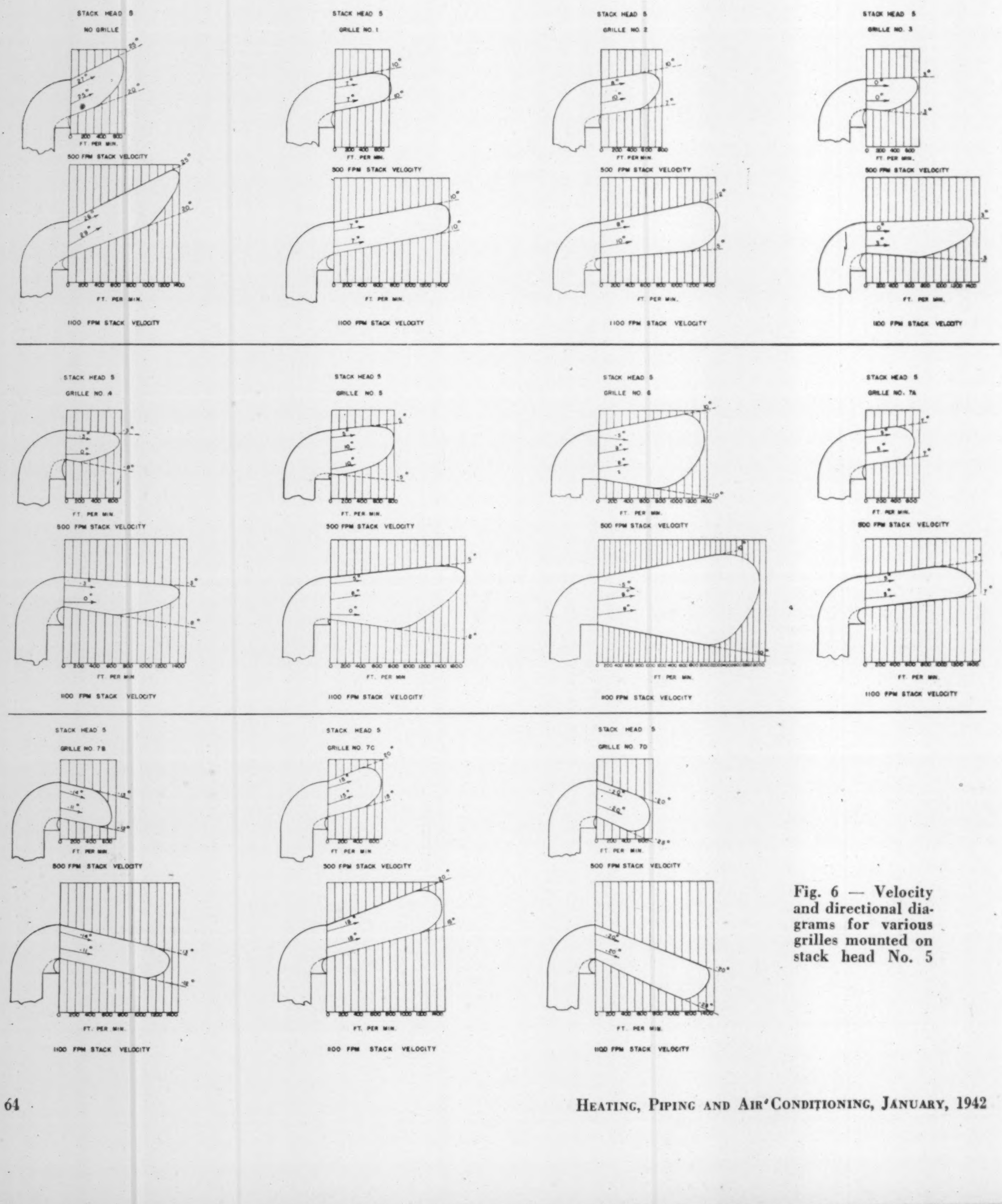


Fig. 6 — Velocity and directional diagrams for various grilles mounted on stack head No. 5

to No. 4 has been reduced by the addition of grille elements at the face, the angle of the air stream has been lowered in the process of spreading it more uniformly over the face. With grille elements having less horizontal guiding length and less free area, greater downward deflection would be expected.

Figs. 13*a* to 13*f* show the discharge from five of the stack head and grille combinations with the aid of smoke. The stack head No. 4 without a grille is shown in Fig. 13*a*, in which the area of negative flow and the upward tilt to the air stream are visible. Figs. 13*b* and 13*c* show stack head Nos. 5 and 6 also without grilles. The negative flow area in No. 6 covers the whole lower half of the stack face area. These photographs show the relative upward tilts of the air stream for stack heads Nos. 4, 5, and 6. Fig. 13*d* of stack head No. 6 with grille No. 2 shows some of the negative area still present, but the angle of flow has been lowered considerably. The higher resistance grille No. 5 mounted on the stack head No. 6 is shown in Fig. 13*e* to have eliminated the negative area and to have given the air stream a downward tilt. The downward tilt is still more pronounced with the high resistance grille No. 6 on stack head No. 6 as shown in Fig. 13*f*.

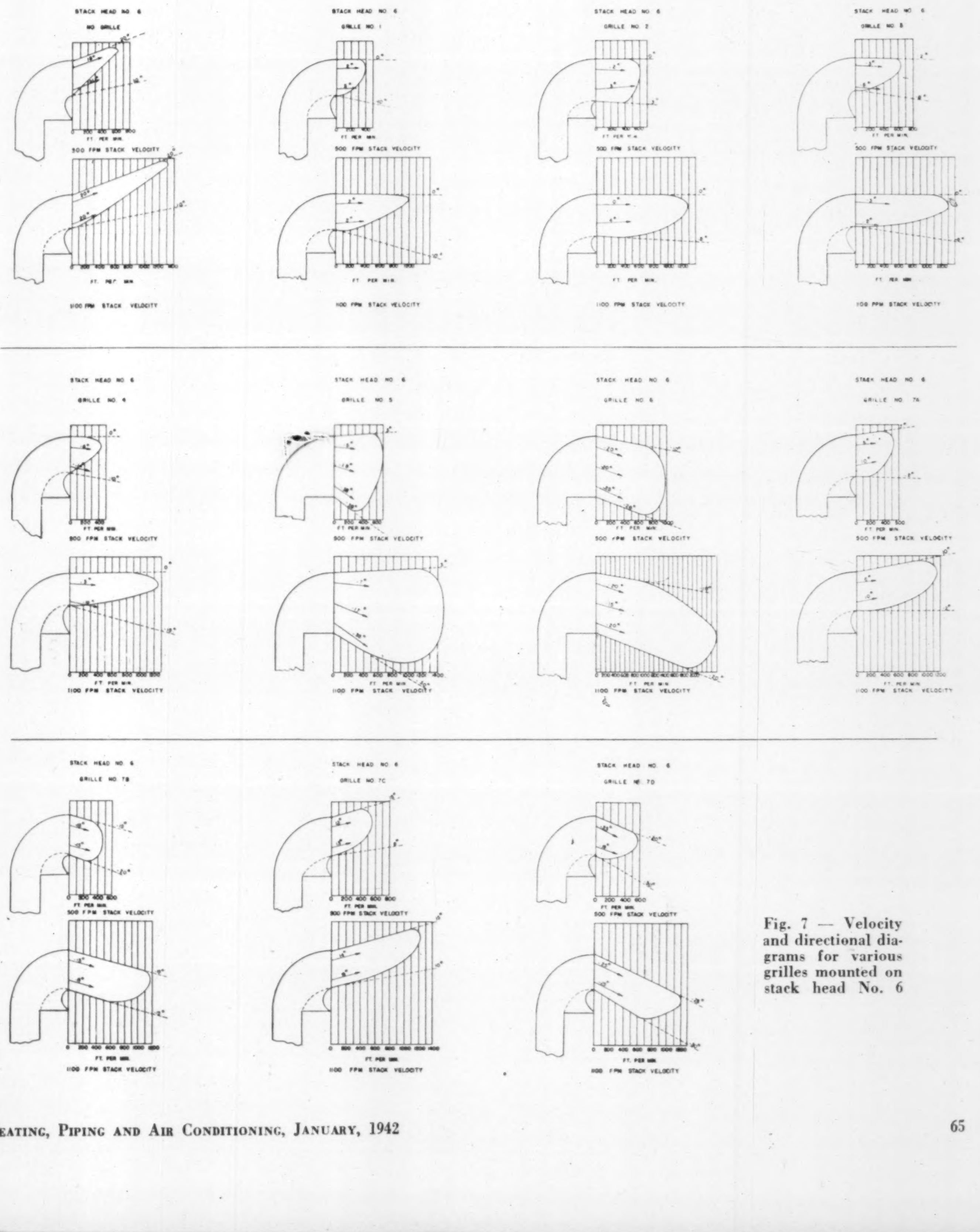


Fig. 7 — Velocity and directional diagrams for various grilles mounted on stack head No. 6

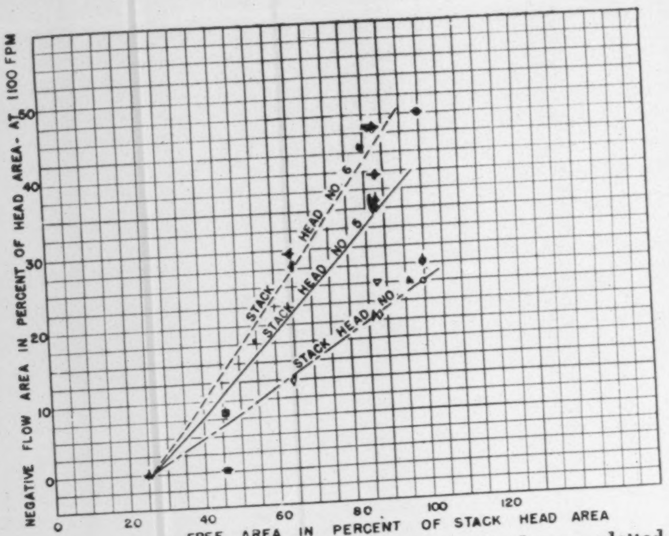


Fig. 8—Negative flow area in per cent of head area plotted against per cent of free area of head for stack heads Nos. 4, 5, and 6

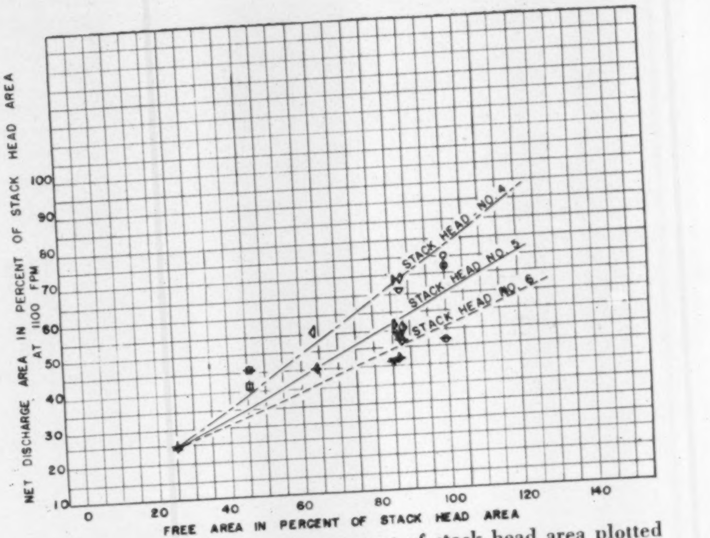


Fig. 9—Net discharge area in per cent of stack head area plotted against per cent free area in stack head

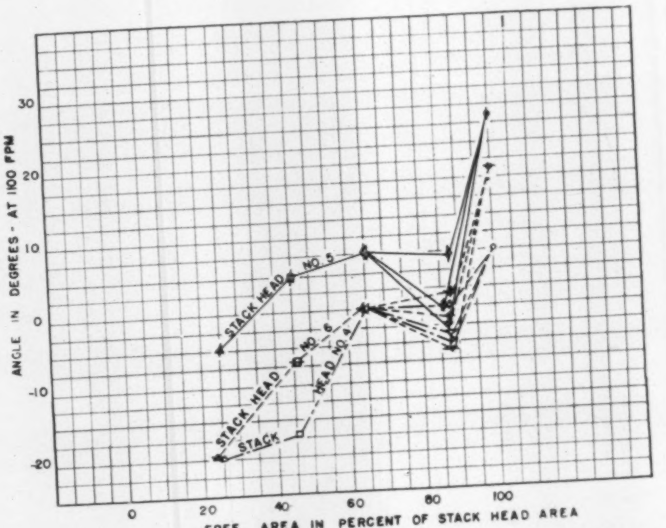


Fig. 10—Discharge angle in degrees plotted against per cent free area of stack head

Table 2—Results of Tests on Grilles with Stack Head No. 4

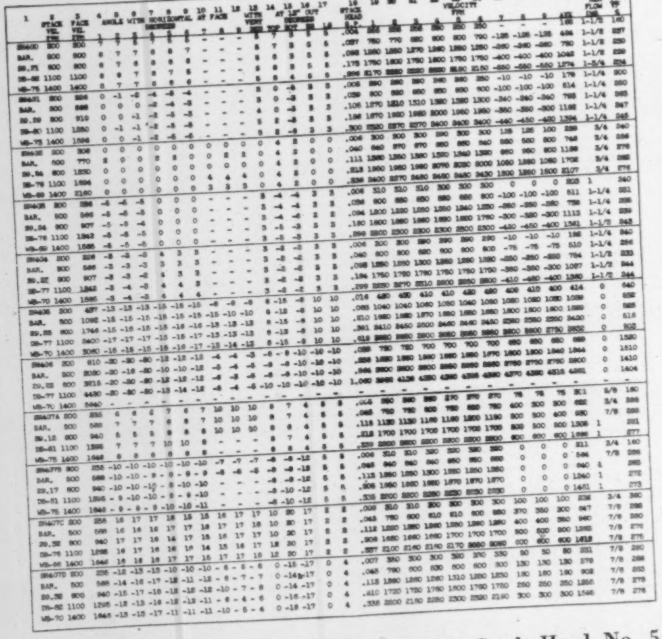


Table 3—Results of Tests on Grilles with Stack Head No. 5

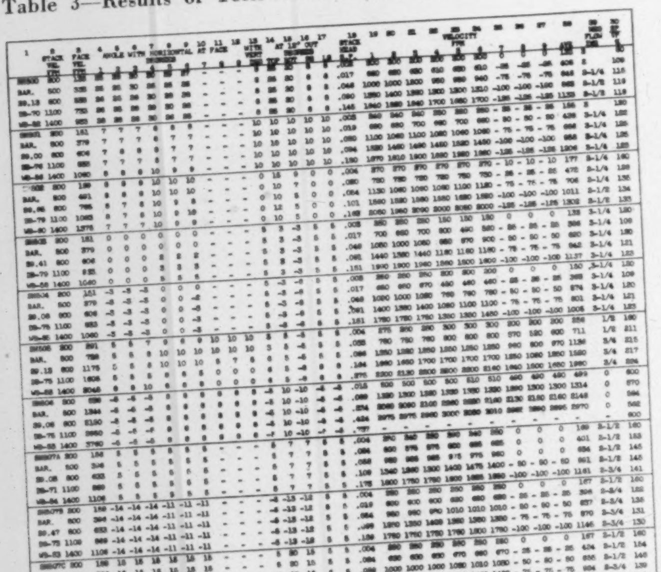
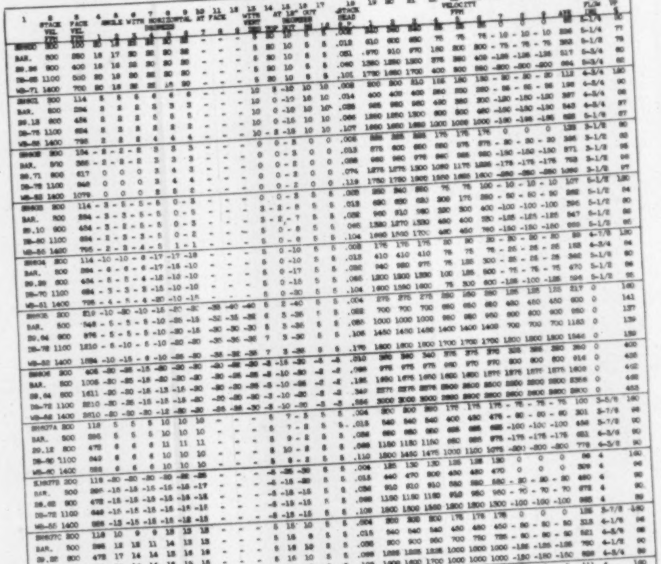


Table 4—Results of Tests on Grilles with Stack Head No. 6



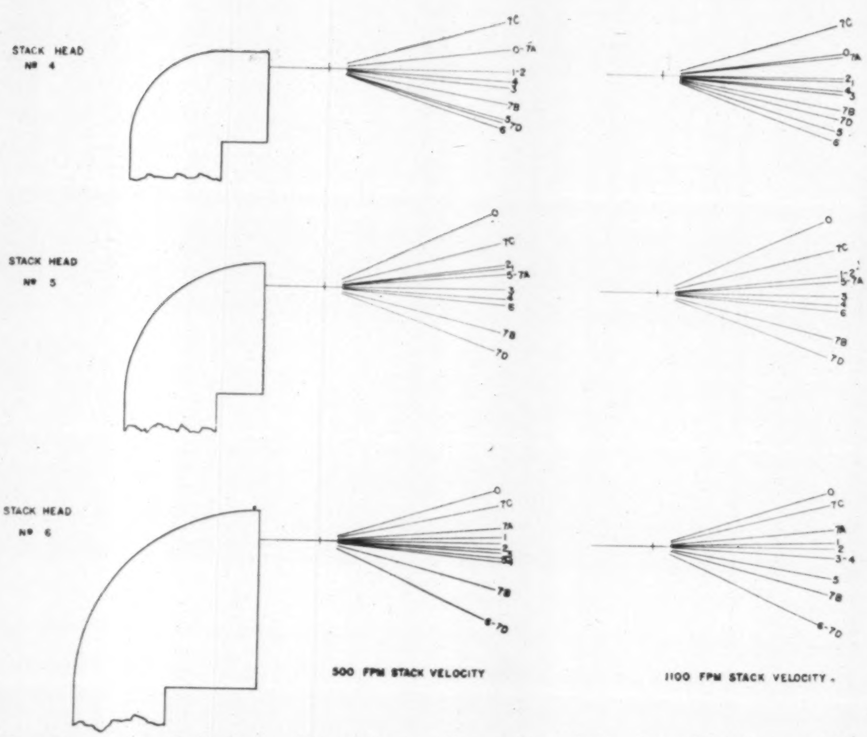


Fig. 11—Angle of discharge for various grilles and stack head combinations at 500 and 1100 fpm stack velocity

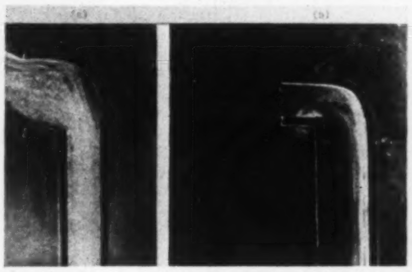


Fig. 12a-b—Air flow in stack heads as determined in flow analyser

A summary of results for the various grilles used on stack head No. 4 is shown in Table 2, on stack head No. 5 in Table 3, and on stack head No. 6 in Table 4. Face velocities in Column 3 were obtained by multiplying the stack velocities by the ratio of stack area to the free area of the grille (Fig. 4) on a face opening. Negative values in Columns 4 to 12 indicate downward tilt of the air stream and in Columns 19 to 27 reverse flow.

Static Pressure Effects

In Figs. 14, 15, and 16 the static pressure at the base of the stack head for stack head Nos. 4, 5, and 6, respectively, are plotted against the stack velocities in feet per minute. From these curves it will be noted that the highest static pressures are found with grille Nos. 5 and 6, while for grille Nos. 1, 2, 3, 4, and 7 the static pressures are only slightly above those for stack heads without grilles. These curves indicate that as the face area is decreased, the static pressures at the base of the stack head are increased, and for any individual stack head the results show that the highest static pressures occur when the stack head is equipped with a grille of the least free area. Grille openings are essentially orifices; therefore, in addition to free area there is the element of coefficient of discharge influencing static pressure at the base of the stack head and grille combination at a given air volume. Pressed grille Nos. 5 and 6 are quite similar as to orifice action. Either one would have a higher coefficient of discharge and lower resistance if used in a reversed direction. The cast-iron grille No. 2, which might be expected to have a high resistance did not have, because of a comparatively high free area and a nozzle-like shape from the draught of the molding pattern which would result in a high discharge coefficient. With grille No. 7, which has a definite directional effect, the static pressure was not increased when this grille was reversed to deflect the air downward rather than upward. In Fig. 17 the static pressures at the base of the stack head are plotted against the negative flow areas in inches.

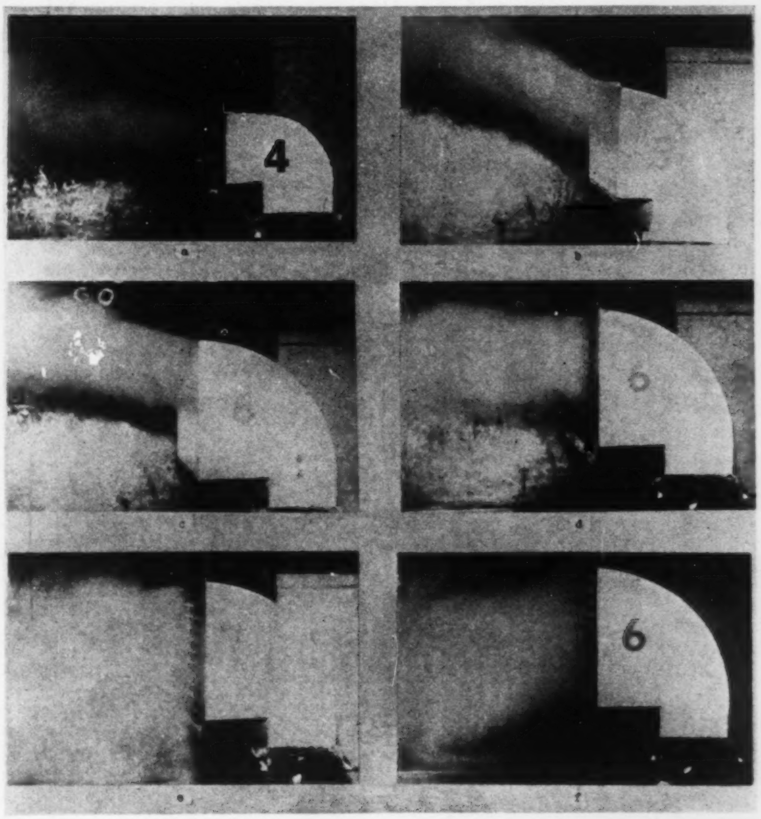


Fig. 13a-f—Photographs of air stream leaving stack heads

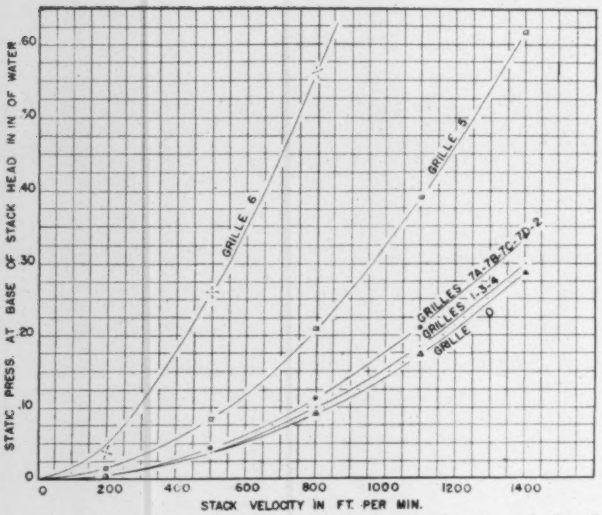


Fig. 14—Variation of static pressure at base of stack head No. 4 with various grilles

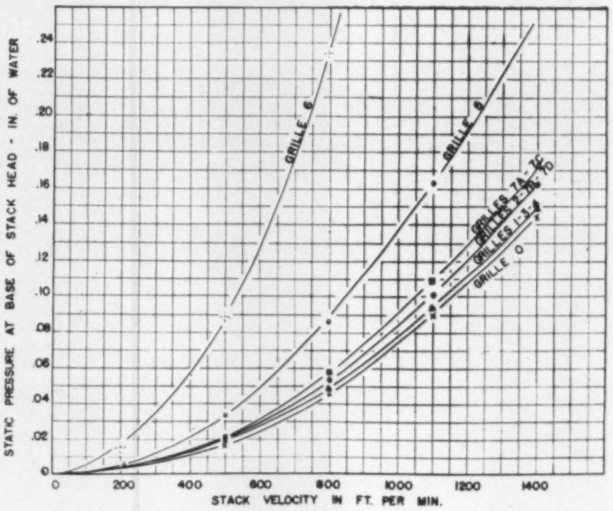


Fig. 15—Variation of static pressure at base of stack head No. 5 with various grilles

The highest negative flow areas result with stack heads without grilles which are also accompanied by low static pressures. The lowest negative flow area results with the grilles having the highest resistance. As the free area of the grille decreases, the static pressure at the base of the stack head goes up very rapidly. The static pressure at the base of the stack head reduces from the highest with stack head No. 4, to the lowest with stack head No. 6 with all the grilles tested.

Conclusions

More uniform flow was found over the face of the stack head with the use of grilles having high resistance than with those having low resistance. Low negative flow area is associated with low face areas of plain stack heads or with the use of high resistance grilles. Reduction of negative flow area results in higher face velocities and reduction of negative flow area by use of high resistance grilles is more pronounced with high face heights.

The angle of discharge from stack heads with various grilles is not influenced appreciably by the velocity in the stack, but is affected by the type of stack head and grille. In general, the angle of discharge is lower with decreased stack head face height and with smaller free area of the grille. With low free areas of grilles negative angles of discharge were obtained. Pressed grilles gave angles of discharge below the horizontal, whereas grilles with horizontal bars resulted in discharge more nearly horizontal.

With decrease in net face area, the static pressure increases slowly at first while the negative flow area is decreasing to zero; with further decrease of free area the static pressure at the base of stack head goes up rapidly. Pressed grilles had the lowest free areas which together with low coefficients of discharge, resulted in the highest static pressures in all cases.

Acknowledgment

The tests on which this paper are based extended over a period of two and a half years, with many of the tests repeated several times. Acknowledgment is especially due to the following students in mechanical engineering for their valued assistance in the program: G. E. Buske, A. C. Holmes, D. L. Hunzicker, C. L. Kaiser, W. H. Rowe, R. W. Seiders, and H. L. Thies.

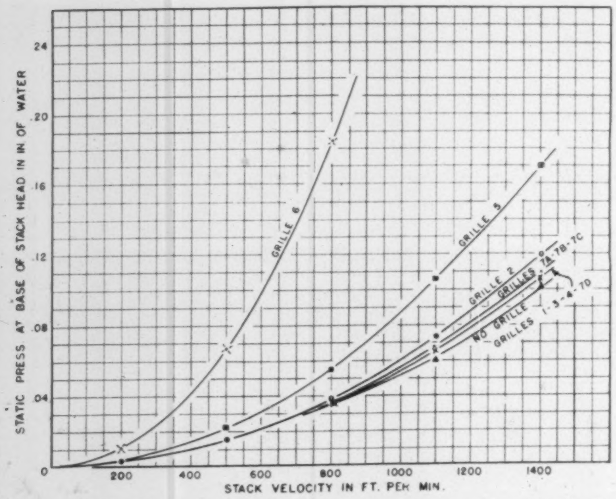


Fig. 16—Variation of static pressure at base of stack head No. 6 with various grilles

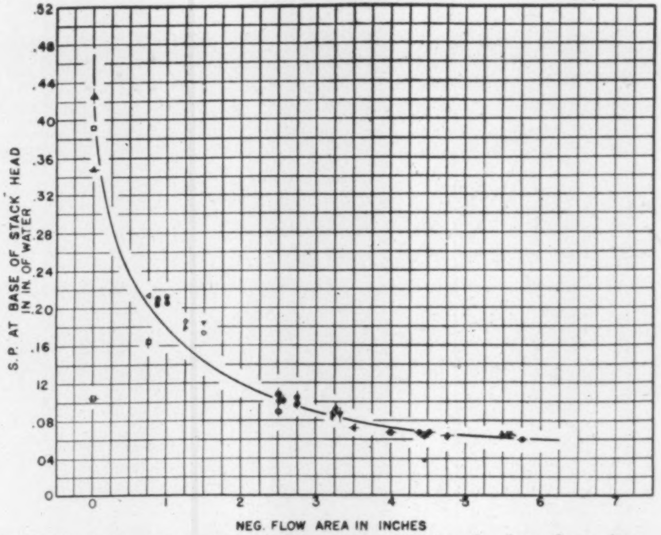
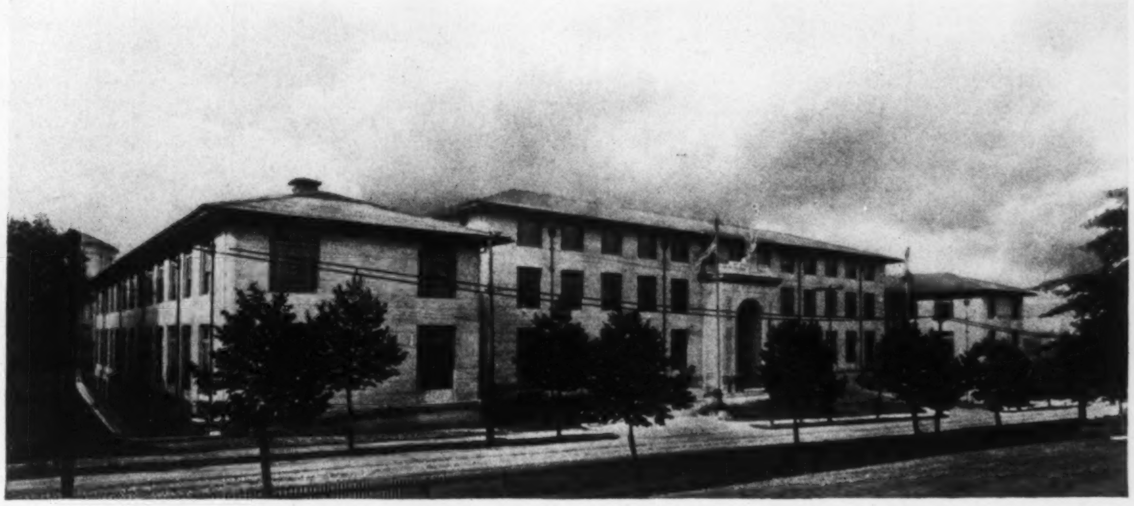


Fig. 17—Static pressure at base of stack head plotted against negative flow area in inches



Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Heat Loss Through Basement Walls and Floors

By F. C. Houghten,* S. I. Taimuty,** Carl Gutberlet† and C. J. Brown††
Pittsburgh, Pa.

SUMMARY—A specially constructed and heated basement was built and a series of thermocouples was sunk in the surrounding earth to observe temperature gradients. Observed heat losses for this particular investigation showed discrepancies with results currently obtained by accepted calculation methods. Some conductivity data for earth are reported

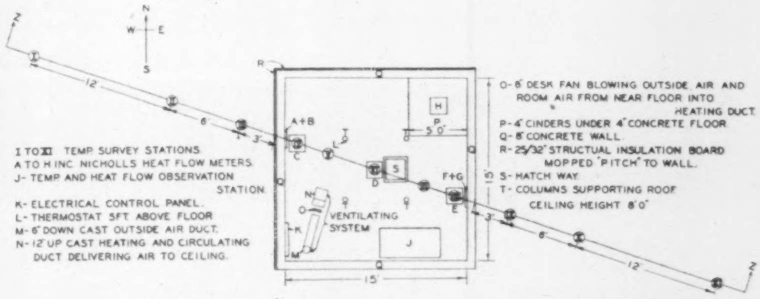
HEAT loss from warmed buildings has been the subject of intensive study which has in general placed heat loss estimates for design purposes on a scientific basis. Some phases of the problem, including heat loss from attics and basements, however, still require further study. The recommended methods for estimating these losses have received little attention, and as a result they are still based on what are practically *rule of the thumb* methods. As an example, the accepted method for estimating heat losses from spaces below the ground level is to assume the transmittance coefficient for the wall or floor in question, including the inside film conductance, and an estimated earth temperature of 45 F next to the outside surface of the wall.

The increased use of basement space for commercial purposes and living or club quarters has made it desirable that satisfactory design data for estimating heating requirements be made available. These data are not only required for the purpose of estimating the heating requirements for maintaining comfort, but also to avoid condensation. In many instances, beautifully designed and decorated basement living quarters have been found unsatisfactory because condensation has spoiled the decorative efforts or flooded the floor. These difficulties arise from the uncorrected practice of building these basement walls of concrete or stone masonry without consideration for their heat transmitting qualities. The correction of this condition must be found in the building of better insulated walls.

The ASHVE Technical Advisory Committee[1] on Heat Requirements of Buildings outlined a program for an initial study of certain aspects of this problem which included the building of a basement at the ASHVE Research Laboratory, incorporating the necessary laboratory facilities for making the desired observations. The results of the study, carried on during the 1940-41 heating season and the following summer, are contained in this report.

Test Set-up

A plan and a vertical section


N
W
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Z
12'
6'
3'
3'
6'
12'
R
A+B
C
D
E
F+G
H
P
5'0"
L
T
S
J
K
M
N
O
Q
15'
15'
VENTILATING SYSTEM
I TO XI TEMP SURVEY STATIONS.
A TO H INC NICHOLLS HEAT FLOW METERS.
J- TEMP AND HEAT FLOW OBSERVATION STATION
K- ELECTRICAL CONTROL PANEL.
L- THERMOSTAT 5FT ABOVE FLOOR
M- 6" DOWN CAST OUTSIDE AIR DUCT.
N- 12" UP CAST HEATING AND CIRCULATING DUCT DELIVERING AIR TO CEILING.
O- 6" DESK FAN BLOWING OUTSIDE AIR AND ROOM AIR FROM NEAR FLOOR INTO HEATING DUCT
P- 4" CINDERS UNDER 4" CONCRETE FLOOR
Q- 8" CONCRETE WALL
R- 25/32" STRUCTUAL INSULATION BOARD MOPPED "PITCH" TO WALL.
S- HATCH WAY
T- COLUMNS SUPPORTING ROOF
CEILING HEIGHT 8'0"

Fig. 1—Plan view of basement and surrounding temperature survey stations

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*Director, ASHVE Research Laboratory. MEMBER of ASHVE.

**Assistant Research Physicist, ASHVE Research Laboratory.

†Assistant Research Engineer, ASHVE Research Laboratory.

††Laboratory Aide, ASHVE Research Laboratory.

For presentation at the 48th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1942.

[1] *Committee Personnel:* Paul D. Close, *Chairman,* E. K. Campbell, J. F. Collins, Jr., E. F. Dawson, W. H. Driscoll, H. M. Hart, E. C. Lloyd, H. H. Mather, C. H. Pesterfield, F. B. Rowley, R. K. Thulman and J. H. Walker.

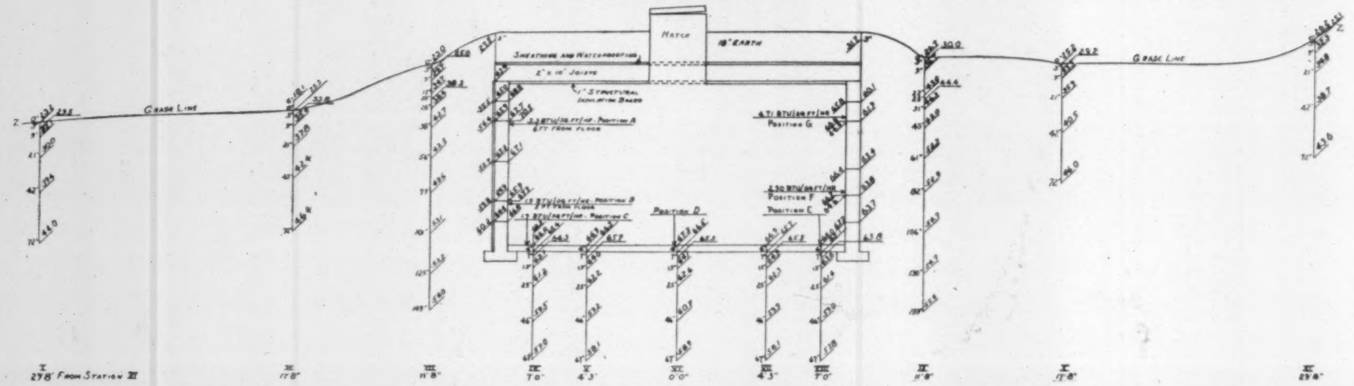
Hatch
18" Earth
Sheathing and Waterproofing
2" x 10" Joists
1" Structural Insulation Board
Grade Line
2.2 BTU/sq ft/hr - Position A
6 ft from floor
1.3 BTU/sq ft/hr - Position B
2 ft from floor
1.3 BTU/sq ft/hr - Position C
Position D
4.71 BTU/sq ft/hr
Position G
2.30 BTU/sq ft/hr
Position F
Position E
I
27'6" From Station II
II
17'8"
III
11'8"
IV
7'0"
V
4'3"
VI
0'0"
VII
4'3"
VIII
7'0"
IX
11'8"
X
17'8"
XI
27'6"

Fig. 2—Temperature and heat flow pattern, Section ZZ, Fig. 1, for February 11, 1941 showing temperature survey stations I to XI, distances below earth or basement floor surface and observed temperatures; also Nicholls' heat flow meter positions *A* to *G* and heat flow observations

through the basement,—which as indicated includes no superstructure, are given in Figs. 1 and 2. The ceiling and roof, which consisted of 1 in. of structural insulation board, 2-in. x 10-in. joists, 1-in. planking and water-proofing, were covered with 18 in. of earth to reduce ceiling losses.

Since heat losses must necessarily be greatly influenced by earth temperatures near the side walls and floor of the basement, a series of thermocouples were sunk to depths of 6 ft or more below the earth surface and basement floor at survey stations I to XI, along the line Z—Z (Fig. 1). At each of the survey stations a number of thermocouples were so placed as to give the temperature gradient from 6 in. above the ground or floor surface downward through the earth. The ground surface couples and those in the earth were in $\frac{3}{16}$-in. O.D. copper tubes so placed that 15 in. next to the junctions were in the isothermal plane. For the couples below the earth's surface this was accompanied by coiling the tubes containing the wire. The location and depth of the couples for each survey station are given in Fig. 2.

The side walls of the basement were 8-in., 1:2:4 mix concrete. The north and west walls were insulated with $\frac{25}{32}$-in. structural insulation board, attached to the outside of the concrete walls by mopping with pitch. The east and south walls were not insulated. The floor consisted of 4 in. of concrete placed directly on the earth, with the exception of a 5 ft x 5 ft section in the northeast corner, which was laid over 4 in. of cinders.

Fig. 3 shows the observation station equipped with a precision potentiometer, selective plug-in switches by which any of the 160 thermo-electric circuits, including those in the Nicholls' heat flow meters, could be read; while Fig. 4 shows another corner of the basement including two of the 2-ft square meters, *A* and *B*, attached respectively, with their centers 2 ft from the ceiling and 2 ft from the floor on the insulated side wall, and a third meter, *C*, attached to the floor. The thermostat, with its sensitive element at the 5-ft level, is also shown.

The basement space was heated electrically by thermostatically-controlled strip heaters placed in a 12-in. square vertical duct taking air from near the floor and discharging it near the ceiling. The space was

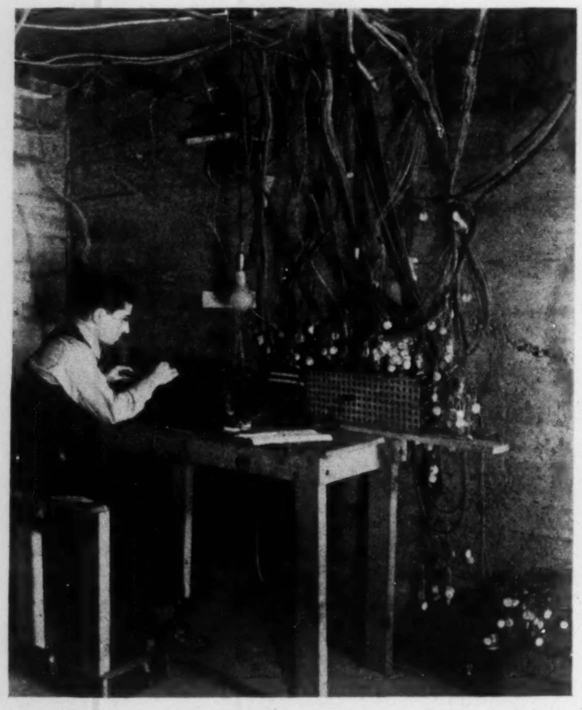

Fig. 3—Interior of basement showing set-up for observing temperatures and heat flow through walls and floor

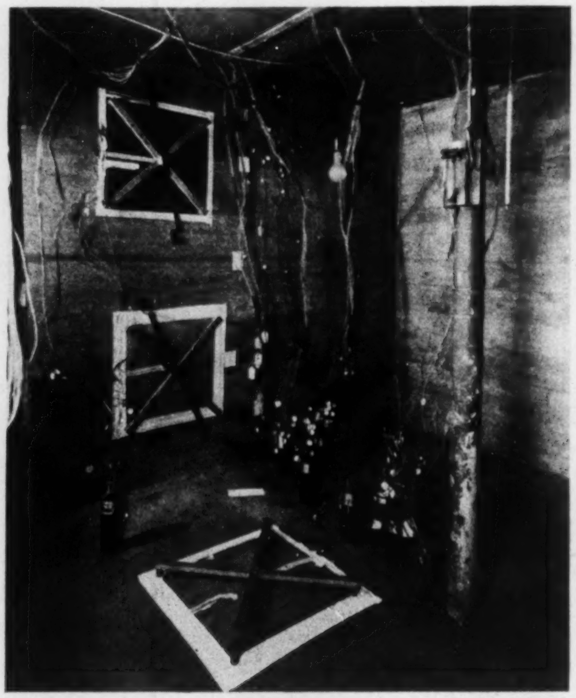

Fig. 4—Northwest corner of basement showing heat flow meters in place at positions *A* and *B* on the west wall and position *C* on the floor. Thermostat is also shown

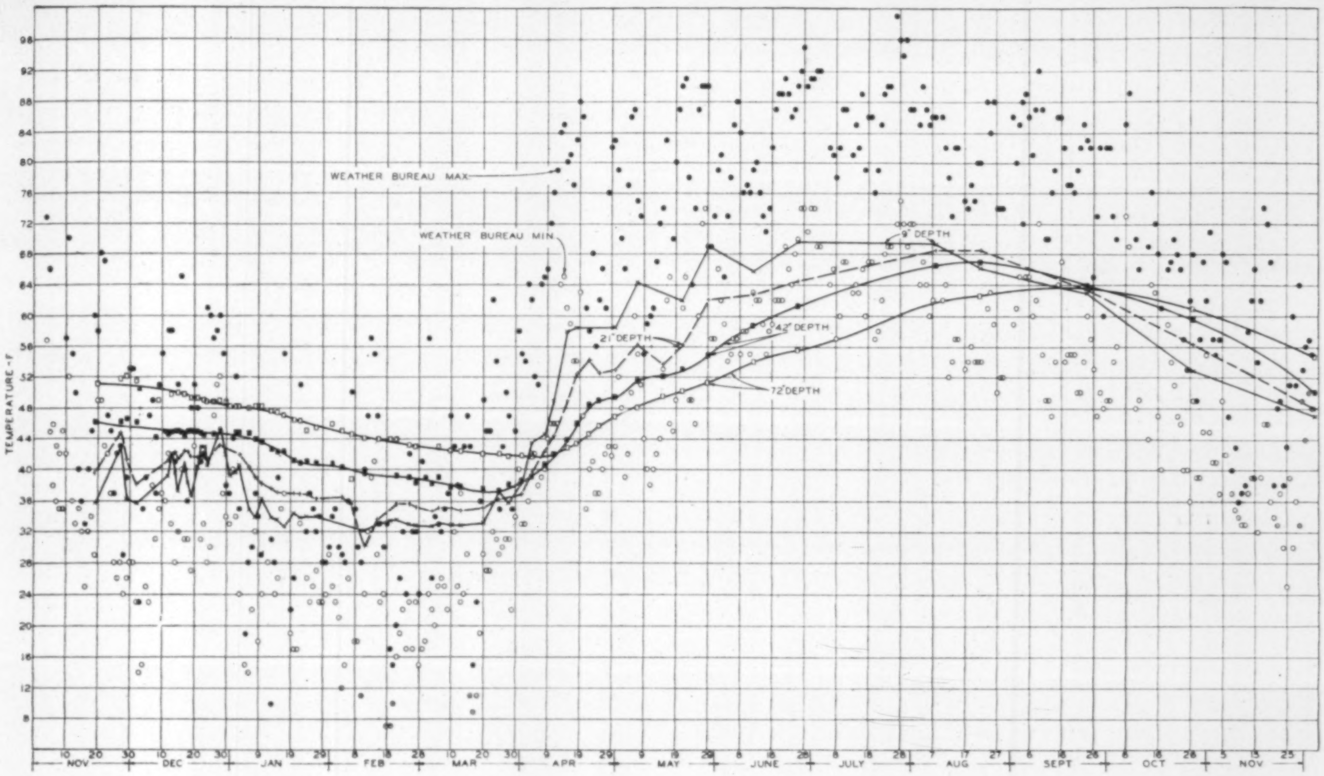

Fig. 5—Log of Weather Bureau maximum and minimum daily temperatures in Pittsburgh and temperatures as observed in survey station I (See Fig. 1) at depths of 9, 21, 42 and 72 in.

ventilated by a downcast, 6-in. duct, leading from the outside down to the floor through an elbow, discharging the cold outside air at a point where it would be *picked up* by the intake of the circulating duct containing the heaters. A desk fan between the discharge from the vent duct and the intake to the circulating and heating duct served to increase the air flow from the floor to ceiling, so as to give approximately a 10-min. recirculation rate for the basement. The outside air supply was controlled by damper to give about 10 cfm. Exhaust air was permitted to escape through the door of the hatch, which was the only means of ingress and egress.

Tests included the observation of the temperatures at all of the points indicated in Fig. 1, including the outside and inside surfaces of the walls and floor, between the insulation and concrete where insulation was applied, and the air 6 in. from the inside of the wall and floor at all points where meters were located.

Test Results

Fifty-four tests were made, first twice weekly from December 23, 1940, to May 1, 1941, and later at less frequent intervals until December 4, 1941. Fig. 5 gives a log of Weather Bureau high and low temperature observations for each day and those observed for each test for points 9, 21, 42 and 72 in. below the ground surface at station I, 21 ft from the outside of the west basement wall.

The following values in relation to the time of the year, for positions *A* and *B* on the west wall, 2 ft, respectively, from the ceiling and floor, are given in Fig. 6: (1) temperature of the air 6 in. inside of the wall, (2) the temperature of the earth 44 in. from the inside wall surface, and (3) the heat flow. Fig. 7 gives similar data for locations *F* and *G*, 2 ft from the floor and 2 ft from the ceiling on the east, uninsulated wall, and Fig. 8 gives the same data for locations *C, D,* and *E* on the floor. This figure also gives the heat flow for the position *H* on the floor where the concrete was placed over the 4 in. of cinders.

The earth temperatures around the perimeter of the side walls and floor of the basement in a vertical plane are given in Fig. 9 as observed at survey station III from the surface of the earth down to a point 38 in. below the basement

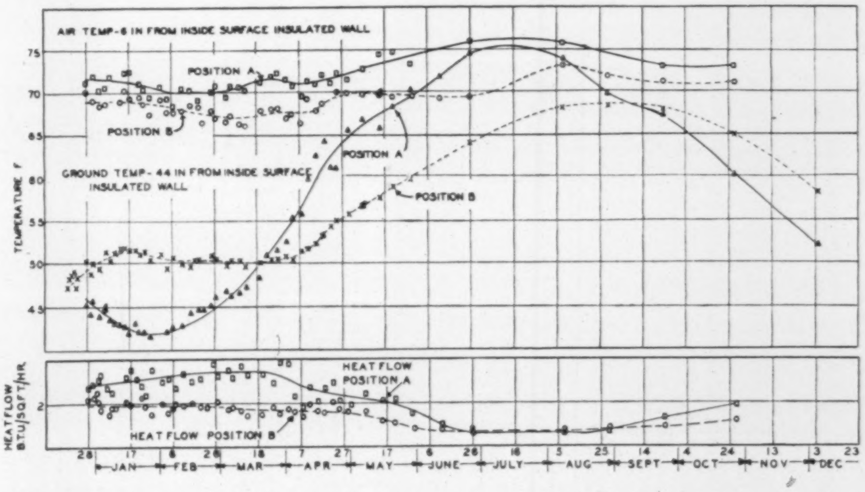

Fig. 6—Relation between time and (1) air temperature 6 in. from inside wall surface (2) ground temperature 44 in. from inside wall surface, and (3) heat flow for positions *A* and *B* on insulated wall

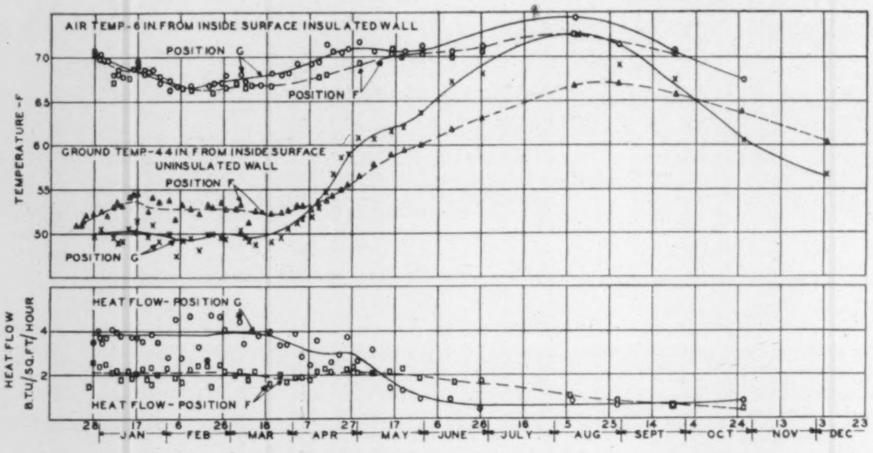

Fig. 7—Relation between time and (1) air temperature 6 in. from inside wall surface (2) ground temperature 44 in. from inside wall surface, and (3) heat flow for positions *F* and *G* on uninsulated wall

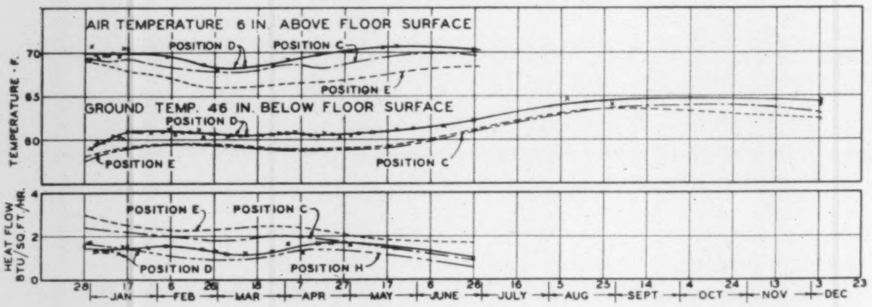

Fig. 8—Relation between time and (1) air temperature 6 in. above floor surface (2) ground temperature 46 in. below floor surface for positions *C*, *D* and *E*, and (3) heat flow for positions *C*, *D*, *E* and *H* on the floor

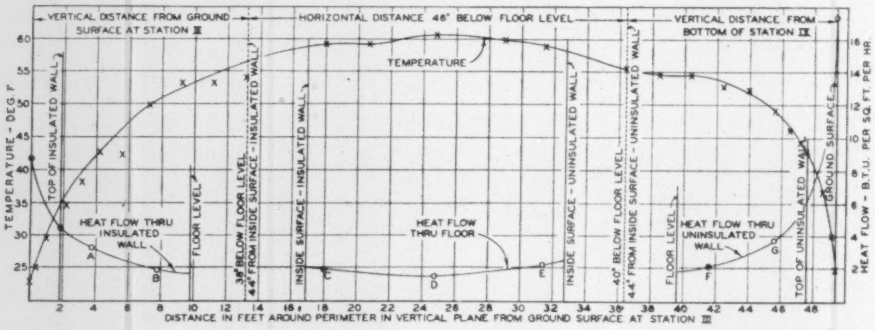

Fig. 9—Earth temperatures around perimeter 44 in. from inside surface of sidewalls and 46 in. below floor surface as observed on February 11, 1941, in survey station III from ground surface down to level 38 in. below floor surface in stations IV, V, VI, VII and VIII, 46 in. below floor surface and in station IX from 40 in. below floor surface up to ground surface

floor level, thence at points 46 in. below the floor level at survey stations IV, V, VI, VII, and VIII, to survey station IX, 40 in. below the floor, and thence upward to the ground surface.

Fig. 9 also gives the heat flow through the inside surface of the walls and floor as measured by the heat flow meters at locations *A*, *B*, *C*, *D*, *E*, *F* and *G*, around this perimeter. The heat flow curves are extrapolated upward to the surface of the earth, this point being plotted as the calculated heat flow through the top part of the wall if the earth in contact with it at that point had been at temperatures observed for the earth surface at survey locations III and IX, respectively.

Table 1 gives the heat flow through different sections of the basement wall on February 11, as determined from the heat flow curves in Fig. 9. The total heat loss for this date is 1,747 Btu per hour as compared with a loss of 13,734 calculated from the accepted assumption that the temperature of the earth in contact with the outside surface of the wall and floor would be 45 F. Temperature and heat flow patterns in and around the basement for February 11, April 11, and August 8, 1941, are given in Figs. 2, 10 and 11.

Discussion of Test Results

The data given in Figs. 2, 10 and 11 indicate the degree to which the earth is warmed around the basement. A continued drop in the earth temperature at the 72-in. level, 21 ft away from the west basement wall from the time of the first observation on November 20, 1940, to April 8, 1941, is shown by the data plotted in Fig. 5. There is then a rise in the earth temperature at this point until about September 22, 1941. It is assumed that at this distance from the basement wall there was no warming of the earth due to the heat in the basement, although Figs. 2, 10 and 11 show some elevation of the temperature in survey stations II and X at distances of 9 ft from the basement, which would indicate that some small effect extends considerably beyond this distance.

The temperature at the 72-in. level, station I, Fig. 5, shows an annual cycle with no observable response to shorter periodic weather fluctuations. The temperature at the 42-in. level shows little fluctuation with changing weather. At the 21-in. level some temperature variation with changing weather conditions is observed, but these changes do not follow daily weather conditions. At the 9-in. level daily changes are observed. The temperature curves for the 21 and 9 in. levels are drawn as straight lines between points since the shape of these portions of the curves could not be determined. At the 3-in. level, at the ground surface and in the air 6 in. above the surface the temperature fluctuations were so violent that the effect could not be shown in the chart and they are therefore not plotted. The air temperature and the temperature of the ground surface followed more or less the hourly changes in weather, while even at 3 in. below the ground surface short period fluctuations were observed; that is, there was a rise in the temperature following a rise in air temperature or increase in sun intensity. A characteristic crossing of the temperature curves for different depths is observed in late March and early April. Prior to this time, or while the earth temperature was falling at the 72-in. level, the ground temperature observed at survey station I generally increased with depth, while after this period the temperature decreased with depth; the only excep-

Table 1—Heat Loss Through Various Portions of the Basement Walls and Floor as Determined from the Heat Flow Curves, Fig. 9, for February 11, 1941

Part of Construction	Section	Insulated Portion of Walls, and Floor Adjoining Insulated Walls					Uninsulated Portion of Walls, and Floor Adjoining Uninsulated Walls				
		Area Sq Ft		Heat Loss Btu/Sq Ft/Hr		Total Heat Loss Btu/Hr	Area Sq Ft		Heat Loss Btu/Sq Ft/Hr		Total Heat Loss Btu/Hr
Side Walls	Top strip[a]	30		4.0		120	30		4.8		144
	2nd strip	30		3.5		105	30		4.0		120
	3rd strip	30		3.0		90	30		3.4		102
	4th strip	30		2.6		78	30		2.8		84
	5th strip	30		2.3		69	30		2.5		75
	6th strip	30		2.0		60	30		2.2		66
	7th strip	30		1.8		54	30		2.0		60
	Bottom strip	30		1.7		51	30		1.9		57
Floor	Outside strip[b]	19.3	3.2[c]	1.90	1.20[d]	40.5	22.3	0.3[c]	2.22	1.30[d]	49.9
	2nd strip	14.0	2.8[c]	1.90	1.20[d]	30.0	16.1	0.7[c]	2.19	1.30[d]	36.2
	3rd strip	13.6	2.3[c]	1.87	1.17[d]	28.1	14.6	1.3[c]	2.14	1.26[d]	32.8
	4th strip	13.1	1.8[c]	1.84	1.14[d]	26.2	13.1	1.8[c]	2.05	1.22[d]	29.1
	5th strip	10.6	1.3[c]	1.79	1.09[d]	20.4	9.6	2.3[c]	1.97	1.17[d]	21.6
	6th strip	8.6	0.7[c]	1.72	1.00[d]	15.5	6.5	2.8[c]	1.89	1.09[d]	15.4
	7th strip	8.3	0.3[c]	1.67	0.97[d]	14.2	5.4	3.2[c]	1.82	1.04[d]	13.1
	8th strip	6.0		1.61		9.7	6.0		1.72		10.3
	9th strip	4.1		1.58		6.5	4.1		1.68		6.9
	10th strip	2.0		1.55		2.1	2.0		1.57		2.1
	Center 0.3 Sq Ft	0.3		1.50		0.5	0.3		1.50		0.5

[a] Walls were divided into foot wide strips, extending around basement parallel to floor.

[b] Floor was divided by diagonal drawn from Northeast to Southwest corners separating portion adjoining insulated walls from that adjoining uninsulated walls; these sections were divided into foot wide strips running parallel to walls.

[c] Area of that portion of strip lying in Northeast Corner over cinders.

[d] Heat flow through that portion of strip lying in Northeast Corner over cinders.

tions to this rule are for the points near the earth's surface where short period weather fluctuations are effective.

It is of interest to note the somewhat higher earth temperatures at the end of 1941 compared with those for the same date in 1940. The temperatures at the 72 and 42-in. levels, Fig. 5, were 55 and 50 F on December 4, 1941, compared with 51 and 46 F, respectively, on the same date, 1940. This difference is probably due to the higher weather temperatures for the three months preceding December 4, 1941, compared with the year before; from September 1 to December 4, 1941, the average daily mean temperature was 2.1 deg above normal, while for the previous year it was 2.8 deg below normal.

The relation between the temperatures at various locations around the basement for February 11, Fig. 2, indicate considerable temperature rise in the earth within 3 or 4 ft of the basement, with some appreciable effect extending to survey locations II and X, 9 ft from the basement. The effect of insulation on the west wall in maintaining a lower outside earth temperature may be observed by comparing temperatures in the survey locations III and IX, opposite the lower portions of the basement. Some of this difference, however, is due to the higher *grade line* to the east of, compared to that west of, the basement. It is also of interest to compare the inside wall surface temperatures for the insulated and uninsulated walls. The two upper inside surface temperatures of the insulated wall were 68.8 and 67.7, respectively, while for the uninsulated wall these temperatures were 65.8 and 64.4 F, respectively.

The effect of the basement in maintaining a higher temperature under the center portion of the floor is also observed. This effect seems to extend to a depth of more than 6 ft below the basement. The effect of the heated basement in heating the ground around it, and therefore decreasing the heat loss is quite pronounced, and indicates clearly the limitation of the application of the assumed 45 F for the earth temperature outside of such walls and floors.

The lag in the rising temperatures with warming of the season is indicated by comparison of Figs. 2, 10 and 11, which give data for February 11, April 11 and August 8, respectively. By April 11 the inside surface of the uninsulated wall was still around 66 F, or not more than a degree or two higher than that observed in February. This is below the dew-point temperature on an 85 F day with 55 per cent relative humidity, an atmospheric condition which may be expected on occasions at this time of the year. Hence, without dehumidification, condensation would form on this wall at times during April and on

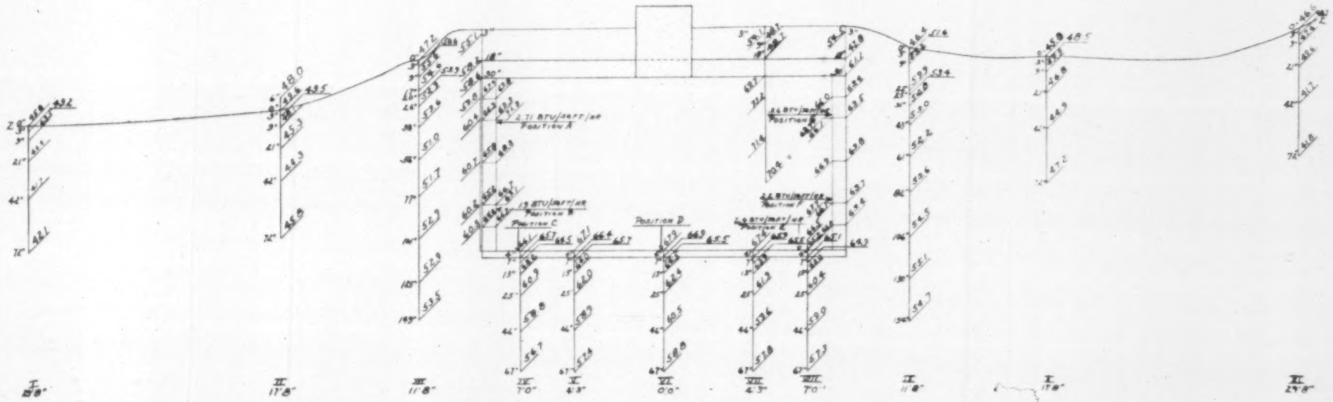

Fig. 10—Temperature and heat flow pattern, Section ZZ, Fig. 1 for April 11, 1941 showing temperature survey stations I to XI, distances below earth or basement floor surface and observed temperatures, also Nicholls' heat flow meter positions *A* to *G* and heat flow observations

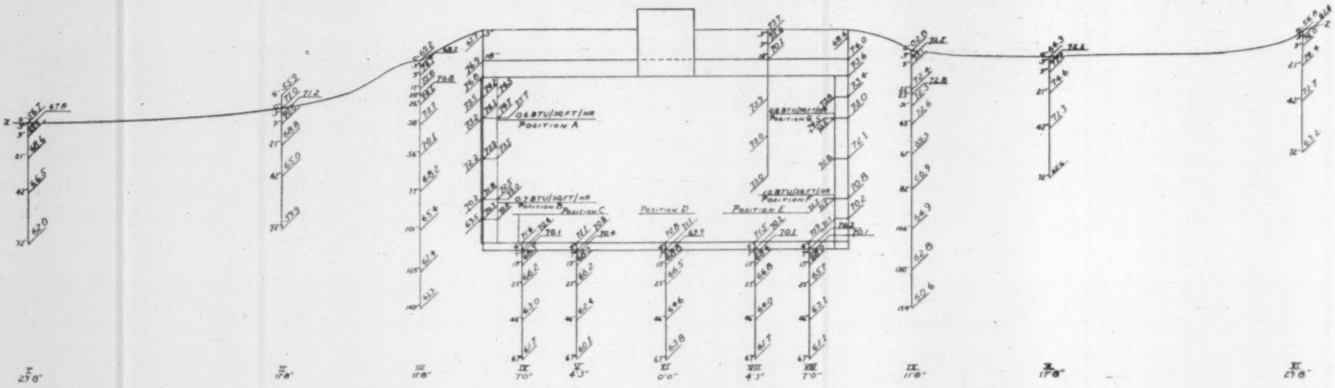

Fig. 11—Temperature and heat flow pattern, Section ZZ, Fig. 1 for August 8, 1941 showing temperature survey stations I to XI, distances below earth or basement floor surface and observed temperatures, also Nicholls' heat flow meter positions *A* to *G* and heat flow observations

occasions throughout the early part of the summer. Even on August 8, Fig. 11, wall and floor surface temperatures in the neighborhood of 71 F were observed, which would result in condensation on a 95 F dry-bulb, 50 per cent relative humidity day.

Condensation did occur on the lower portion of the uninsulated wall to the extent that it was continuously damp near the corners and floor from sometime in April until close to the first of August. Noticeably less dampness was observed on the insulated wall, excepting along the floor line, where some condensation was observed. At the floor line, and more particularly on the floor near the insulated wall, there was more condensation observed than elsewhere. This may be accounted for by the lower earth temperature outside of the insulated wall due to the insulation itself and the resultant conduction of heat away from the floor around the lower edge of the insulation. From this consideration it may be assumed that more insulation, or greater resistance to heat flow, was required to avoid condensation, and that, to be effective, this added resistance to heat flow should be applied to the floor as well as to the side walls.

A comparison of the curves in Figs. 6, 7 and 8 indicates the effect of the insulation in spreading the temperature difference through the insulated wall as compared with the uninsulated wall. The effect was to increase the inside surface temperature and decrease the outside surface temperature. While the reduction in heat flow indicated through the insulated wall was not great, it was nevertheless important in reducing the noticeable condensation.

The large discrepancy between the observed heat loss and that calculated by current accepted methods is of interest, but must be taken with some reservation when applied to intermittently heated basements.

The conductivity of earth is of interest and some observations of its magnitude were made. It is obvious, however, that since there was a continual change in earth temperature, and therefore in heat storage, conductivity values could not be determined in this study with a high degree of precision. However, it was possible to make some calculations, the results of which are contained in Table 2. It will be noticed that these determinations for locations *A, B, D* and *F,* where the flow of heat should be most nearly parallel and constant, give values ranging from 6 to 8 Btu per hour per square foot per degree Fahrenheit temperature difference for 1 in. of thickness. It is of interest to note that this value differs little from a value of 8.5 previously reported[2] by the ASHVE Laboratory for about the same type and condition of earth. It is of further interest that the conductivity value is considerably lower for earth than for concrete. Hence, a concrete wall of a basement, backed by earth of the character studied, serves only to make an enclosure and to support the building. The surrounding earth itself offers more resistance to heat flow than the same thickness of concrete.

While this paper gives some important information on ground temperatures around a heated basement, and the effect of this warming of the ground in reducing the heat loss, it should be emphasized that these effects must be in some measure a function of the earth characteristics, including the character of the soil, the ground water level, and the possible presence of spring water flowing through the earth near the structure. In this study the earth was a red clay to a depth of 2 ft below the basement floor, and from there downward, sandstone. The basement was dug about 200 ft from a ravine cutting at least 50 ft below the level of the basement, which probably accounts for the fact that no ground or flowing water was observed at any time at the opening especially left in the basement floor for that purpose. Undoubtedly, the temperatures and heat flows observed would have been altered by different earth characteristics, and to a greater extent by the presence of a higher ground water level or seepage of cold spring water through the earth near the basement. However, while these effects would necessarily alter the magnitude of the results, the tendency observed would be the same. Whether additional studies in other locations should be made will depend upon the commercial value of the results.

Table 2—Thermal Conductivity of Earth as Determined by Heat Flow Through the Earth Back of or Below the Meters

Position	Heat Flow Btu/Sq Ft/Hr	Temperature of Outside Wall Surface Deg F	Earth		Temperature Difference—Outside Wall to Earth Deg F	Thickness of Earth Inches	Conductivity[b]
			Temperature Deg F	Level[a]			
A	3.00	58.1	41.9	38	16.2	36	6.67
B	1.70	59.6	50.0	77	9.6	36	6.37
D	1.10	66.9	60.5	46	6.4	42	7.22
F	2.00	63.1	52.9	82	10.2	36	7.05

[a] Inches below ground surface.
[b] Btu per square foot per hour per degree temperature difference for 1 in. thickness.

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[2] Additional Coefficients of Heat Transfer as Measured Under Natural Weather Conditions, by F. C. Houghten, Carl Gutberlet and C. G. F. Zobel. (ASHVE Transactions, 1929, Vol. 35, p. 151).

Design and Performance of a Direct-Fired Unit Heater

By R. M. Rush* and H. A. Pietsch**, Pittsburgh, Pa.

SUMMARY — Development of direct-fired unit heaters for gas and oil fuel are traced and test data are given for units of a 1,000,000 Btu capacity. Heat balance data are given for two tests. A novel method of measuring temperature gradient in industrial buildings is also described

DIRECT-FIRED unit heater applications are comparatively new in American industry. With the advent of steam unit heaters, which were introduced about 1918 and came into general use about 1926, industrial heating problems were greatly simplified. As the unit method of heat distribution came into wider use it was natural that the demand came for an efficient direct-fired unit for places where steam was not available or was not economical. The requirements of such a unit were that it be suitable for suspension if necessary, or if of the floor type, that it occupy comparatively small floor areas; that it be capable of firing at good efficiency either with oil or with gas, and that it be dependable and safe to use. The purpose of this paper is to trace the development in the designs of some large direct-fired heaters.

Cast-iron and welded steel warm air furnaces were of course in general use, but because of their large space requirements and their low efficiency, were not suitable for industrial unit heater applications. In 1933 when the development to be described was started, unit heaters firing natural gas were in use, but in general they were limited to the suspended type and to small capacities (of the order of 100,000 to 300,000 Btu per hour), and were not suitable for firing with fuel oil. An unfilled need therefore existed for a compact unit which would be suitable for either oil or natural gas firing.

Thus in 1933 there was little experience on which to base a design for 20 oil-fired units, each having an output capacity of 750,000 Btu per hour, for use in the sheet storage building of a steel company. Fig. 1 shows the design first adopted. The combustion chamber was made of corrugated sheet steel in the shape of an inverted U. Fans located near the floor caused air to circulate upward, over the rounded top of the chamber and then downward, discharging at the bottom of the other side as shown in the illustration.

The combustion chamber was lined about half-way up, with insulating fire brick, and the gases of combustion were drawn down on the outside of this lining, through the space between it and the corrugated steel shell, to a central flue running lengthwise of the bottom of the heater, by means of an exhauster mounted on the same shaft as the blower fans and of course driven by the same motor.

Early in the experiments with this unit, which was oil fired, it was found that the heating surface, consisting of plain corrugated sheet steel, was very apt to overheat and to burn up. After many trials of various means for overcoming this trouble, the problem was solved by the means shown in Fig. 5. This consisted in welding to the corrugated sheet shell a multiplicity of vertical fins, each fin having a vertical deflector bent back toward the outer casing. This construction acts in a number of ways to increase the heat abstraction from the corrugated sheets. It might be thought that the only effect of the deflectors is to increase the velocity of the air, but such is not the case; their chief function is to hold that air in contact, or throw it back into contact with the corrugated sheet and to force it to flow in the corrugations, especially when passing over the rounded top where the air tends to hug the outer casing. The deflectors also increase the turbulence of the air stream at the place where it is most effective for wiping off the stagnant film of air from the corrugated sheet; it is thought that vortex sheets are formed in the air stream at the trailing edge of each deflector, and are forced into contact with the corrugated surface by the air stream constrained by the succeeding deflector. The fins, being welded to form a metallic joint with the corrugated sheet, conduct heat outward and dissipate it to the air stream; calculations based on the theory of heat conduction show that the fin surface should be about 55 per cent to 60 per cent as effective per unit of area as the corrugated surface. The deflectors also act as secondary heating surfaces, receiving heat by radiation from the sheet and dissipating it to the flowing air; in doing so, they act as radiation shields with respect to the outer casing, which accounts for the very low percentage of heat loss from the latter.

That a high velocity of the air was not of itself sufficiently effective was shown by a trial in which the same fins were used but the deflectors were omitted and the outer casing was moved closer to the corrugated sheet; although the true air velocity was as high or even higher than with the deflectors, overheating of the sheet persistently occurred at some places, notably in the curved top part.

One does not ordinarily think of heat transfer to a gas such as air as being at all of the same order of magnitude as heat transfer to a liquid such as water, as for example in boilers; hence it is of interest to note that with the fins and deflectors the average heat transfer attained the value of approximately 6000 Btu per square foot per hour, which is of the same order as that usually attained in low pressure steam heating boilers.

Heaters of the original design,

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*Manager, Industrial Dept., Dravo Corp.

**Chief Engineer, Heater Dept., Dravo Corp.

For presentation at the 48th Annual Meeting of the American Society of Heating and Ventilating Engineers, Philadelphia, Pa., January, 1942.

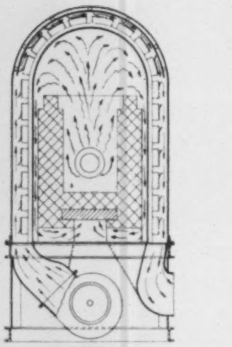


Fig. 1 — Cross-section of heater as built in 1933

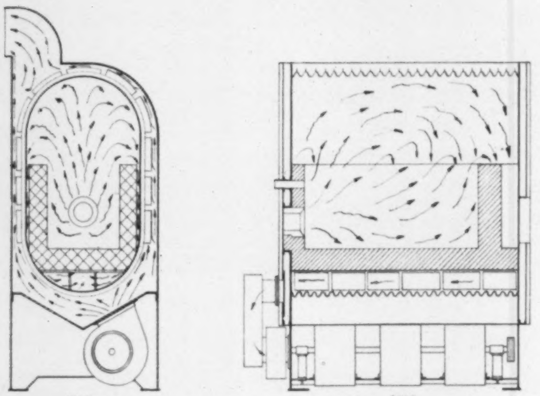


Fig. 2—Cross-section and longitudinal section of heater as built in 1937

Fig. 1, discharged the warm air at the floor level. This was considered advisable for the mill storage buildings as it would keep the steel sheets warm and free of condensation, but was not suitable for locations where the operators would be in the path of the warm air stream. Fig. 2 shows a design similar to the conventional floor type steam unit in that the cold air was taken from the floor and the warm air discharged through adjustable nozzles with louvers approximately 10 ft above the floor line. As compared to the original design, it will be noted that the bottom of the combustion chamber was made rounded the same as the top, and was air-swept; thus the effective heating surface was increased without increasing the over-all dimensions.

The combustion chamber was located off center in order to equalize the air resistance on the two sides.

Because of the difficulty of getting the air to scrub effectively that portion of the heating surface at the top where the air stream from the two sides converge and turn to enter the outlet nozzles, this part of the combustion chamber was very sensitive to overloads, and sometimes due to improper burner adjustment combined with overloads the corrugated sheet at this point was actually destroyed.

Other objections were with width of the unit, and the comparatively high power consumption. Due to the necessity for having insulating fire-brick walls in the combustion chamber at least 9 in. thick on each side, the width could not be reduced below 4 ft, plus 6 or 8 in. for the panel board, and in many places this width was quite objectionable. Due to the lack of streamlining of the combustion chamber, the friction loss was high, and the power required was 7½ hp as compared with 5 hp for a steam unit heater of the same capacity, namely, 1,000,000 Btu per hour.

In the fall of 1939, the design was further improved as shown in Fig. 3. Tube surface in the form of an economizer or air preheater section was added just above the outlet of the fans. Extensive tests were run on the effect of the tubes in cooling the gases and on the effect of twisted steel strips located in these tubes, known as *twisters*. These broke up the warm core of the gases, forced them to the outside of the tubes, and increased their turbulence in contact with the tube surface; increasing the heat transfer rate to such an extent that the exit temperatures were reduced by an additional 90 to 100 F. The latter is a more significant figure than at first appears, since 100 deg drop is relatively difficult to obtain at gas temperatures as low as 400 or 500 F for the reason that the *heat head* or temperature difference between the gases and the air is comparatively small.

With this design, efficiencies exceeding 80 per cent were attained in three units built to heat a hangar for the U. S. Navy, at an output of 1,500,000 Btu per hour each, when fired with heavy oil.

In view of the favorable results obtained with the combination of tube surface with the conventional heating surface, a program of research was inaugurated to develop a heater combining tubes and a refractory lined combustion chamber that would overcome the objections to the previous model. In the spring of 1941, the design shown in Fig. 4 was evolved. The corrugated heating surface with fins and deflectors was of course retained, but the combustion chamber was streamlined in shape. The thick fire-brick lining was replaced by a thin monolithic shell of plastic refractory, in intimate contact with the corrugated sheet, the refractory shell being thin enough to transfer a considerable amount of heat by conduction. Thereby the width of the combustion chamber and of the unit over-all could be reduced at least 12 in., and the narrower combustion chamber could be more easily streamlined to decrease the air resistance. Even with the tubes interposed in the path of the air, it was found in exhaustive tests that the over-all resistance to air flow was so lessened that a 5 hp motor could be used on a

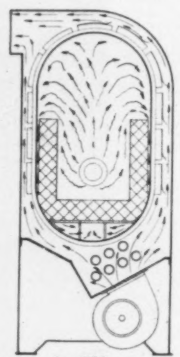


Fig. 3 — Cross-section of heater as built in 1939

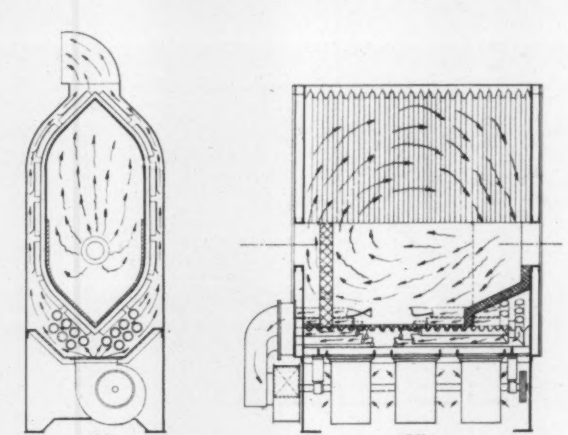


Fig. 4—Cross-section and longitudinal section of re-designed heater as built in 1941

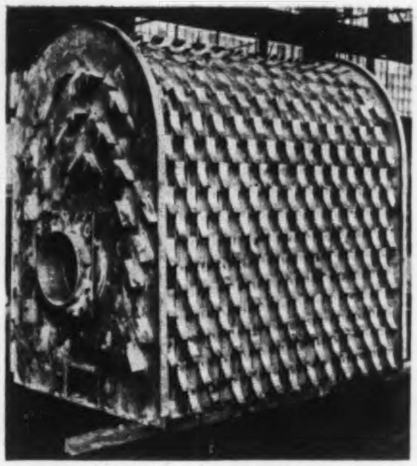


Fig. 5—Corrugated shell with fins and deflectors (1933 Model)

heater having an output of 1,000,000 Btu per hour, as compared to 7½ hp in the older design.

By the use of the pointed top in the combustion chamber, the dead space where the air stream from the two sides converged was eliminated, and all parts of the surface were scrubbed by turbulent air; at the same time the intensity of the radiation per unit of area at this place was decreased, both because the peak is farther from the flame and because of the inclination of the surface (Lambert's Law). Furthermore, impingement of the flame is less likely to occur in the *V* than on a broad rounded surface. As a result of all these factors, over-heating at the point of air outlet was entirely overcome.

This design provided such other advantages as: avoidance of short-circuiting of the gases to the outlet; easier cleaning of convection surfaces; the possibility of installing the refractory lining at the factory rather than in the field; and reduction of heat storage in the refractory, with decreased danger of overheating the metal when the fans shut down. So much heat was stored in the 1700 lb of insulating fire brick of the older design that the fans had to be operated long after the fuel burner was shut off in order to prevent overheating of the corrugated sheet; and electric power was wasted thereby.

In the 1941 design, the smaller weight of refractory makes it possible to operate the blower fans, off and on with the fuel burner, without danger of overheating the metal. Automatic spark ignition for the gas pilot prevents the latter from being extinguished if the combustion chamber becomes filled with products of combustion after the heater has shut down; and the change of location of the instrument and switch panel, as in Fig. 6, meant a reduction in heater width of 8 in., making the over-all width 3 ft.

In a heater of this type the refractory lining becomes glowing hot, which insures continuous ignition of the flame, and keeps the latter out of contact with cold surfaces, and by its radiation speeds up combustion. Since combustion takes place within a gas-tight welded steel chamber, under conditions of carefully controlled draft, there is little chance for infiltration of excess air. The conditions are equally good for the combustion of either gas or oil, and either fuel can be used by a simple change of burner, or a combination gas and oil burner may be used. For natural gas, standard equipment consists of a premix type of burner taking air from the blowing fans of the unit. In the case of oil burners, if light oil is to be used, a standard pressure type burner, with electric ignition, is used. For heavy oil, it was formerly necessary to use combination gas and electric ignition to insure automatic operation, but within the last two years development work in collaboration with a burner manufacturer has resulted in an oil burner in which only electric ignition is required. An electric resistance heater is embodied in the burner tube, and this keeps the oil hot up to the burner tip. The fuel is atomized by compressed air from a small rotary compressor integral with the burner. It is thus only necessary that heavy oil such as Bunker *C* be furnished at a temperature allowing it to flow freely; the burner then handles it automatically with simple electric ignition. By means of the compressed air, modulating pneumatic control is obtainable on the burner, which in the case of heavy oil is more desirable than off-and-on control, the thermostat modulating the fuel supply to a rate just sufficient to hold the required temperature.

Under usual conditions of installation of heaters of this type, the radiation loss or the heat dissipated from the outer casing is not truly a loss, since it is utilized for heating the building. Hence, the only losses are the sensible and latent heat in the flue gases. Even when the conditions are such that the heat dissipated from the outer casing is not utilized, the loss is small, since previous tests of a similar heater showed that it did not exceed 0.8 per cent of the heat input.

Testing of the Re-Designed Heater

Early in 1941 a laboratory was set up in Pittsburgh and a 750,000 and a 1,000,000 Btu heater were installed. Arrangements were made for testing with both oil and gas. Daily test runs were made for several weeks during the summer. A full mechanical crew with electric welding equipment was available in order to make changes quickly. Observation openings were provided, by removing small sections of the outer casing and replacing with glass, giving the effect of windows. Twelve such observation ports on each heater were suitably located to permit observation of those points on the corrugated shell which previous experiences indicated were likely to become the hottest. The heaters were run continuously at overloads of as much as 30 per cent above their rated capacity, but observations indicated no hot spots in the surface surrounding the combustion chamber. Even distribution of air flow over the heating surface is essential in this type of heater, and the absence of overheated spots indicated that this objective had been attained in the re-designed heater.

The test set-up was as shown diagrammatically in Fig. 7. The quantity of air being heated was measured by Pitot tube traverses in four 16-in. diameter ducts leading

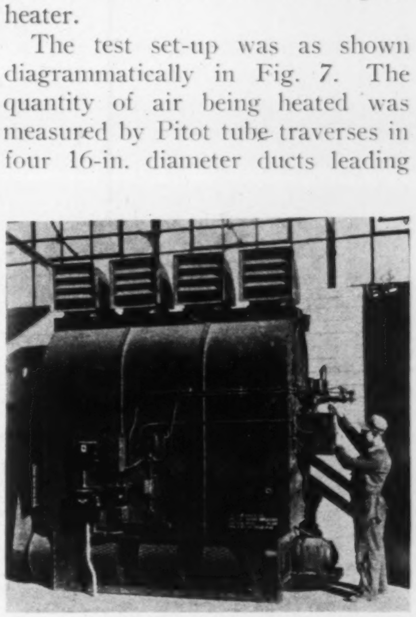


Fig. 6—1,000,000 Btu unit with panel board at side

horizontally from the four outlets of the heater. The distances from the Pitot tube location to the outlet of the heater and to the open end of the duct were somewhat in excess of the minimum prescribed in the standards of the *American Society of Mechanical Engineers.* The traverses were made according to the standard method, two across each duct at 45 deg to the horizontal and at 90 deg to each other; the 10-point method being used, with zones of equal area. Temperature readings at the heater outlets were erratic because of the turbulent conditions there, and for this reason the final air temperatures were taken at the same place as the Pitot tube traverse. Ten readings of temperature were made in each outlet duct, at the same stations as those for the Pitot tube readings, in order to determine the average. Calibrated glass thermometers were used for these as well as for the inlet temperatures. The average of eight inlet air temperatures was taken as the true value.

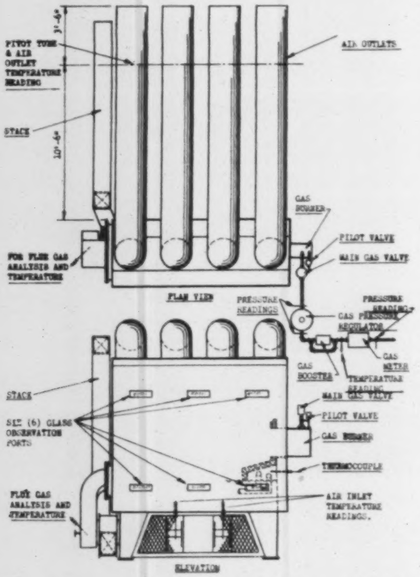


Fig. 7—Diagrammatic sketch of testing arrangements, showing location of instruments

The air quantity was also checked by two other methods, namely by use of the characteristic curves supplied by the fan manufacturer, showing cubic feet per minute for given shaft input horsepower and revolutions per minute; and by calculation from the heat balance and the measured air temperature rise, involving determination of the heat losses from the casing and in the flue gases.

The quantity of natural gas burned was measured by a calibrated displacement meter. The temperature and pressure of the gas were measured at the meter, and the volume corrected to standard conditions. The analysis and the calorific value of the gas were supplied by the local gas company.

The temperature of the gases leaving the heater was measured by a mercury thermometer, and Orsat analyses were made of samples taken at this point, determining CO_2, O_2, and CO. The temperature of the gases entering the economizer was measured by a thermocouple and potentiometer.

The motor efficiency data were furnished by the manufacturer and the amperes input, voltage and power factor were determined by instruments furnished by that company. Motor speed and fan speed were taken with a revolution counter.

Pressures (or drafts) were measured in the combustion chamber, before the economizer, and in the outlet stack.

The test procedure was to allow the heater to warm up for at least one hour, then take data at 15-min intervals for a period of 2 hours or more, for each test.

The results of the tests on the larger heater rated at 1,000,000 Btu per hour output capacity, fired with natural gas, are shown in the accompanying set of curves, Fig. 8, which represent the average of the many tests corresponding to the plotted points.

Table 1 gives the data and heat balance for a test at approximately 1,000,000 Btu output per hour. Table 2 is for a test at 1,250,000 Btu output per hour.

Discussion of Results of Tests

It will be noted that the motor horsepower required for 1,000,000 Btu per hour output was the 5 hp aimed at in the design. It will also be noted that the thermal efficiencies, even at 30 per cent overload, are all above 80 per cent. When firing natural gas in any apparatus having heat-transmitting walls of iron or steel, the gases must not be cooled to such a temperature that condensation will occur, otherwise rapid destruction by corrosion will occur. In view of the fact that the loss due to the latent heat of the water vapor formed by the combustion of natural gas amounts to about 10 per cent of the higher, or gross calorific value, the efficiency referred to the latter value could not, even under ideal conditions, exceed 90 per cent with natural gas. The test efficiencies, therefore, are in reality of the order of 90 per cent of this maximum attainable value.

After completion of the test in the Pittsburgh laboratory, a standard 1,000,000 Btu heater was shipped to Cleveland and tested for *AGA* approval. In these tests, safety is the main consideration. No heater of such large capacity had previously been tested in the *AGA* laboratories, but the tests were successfully completed and the unit when equipped with controls described bears *AGA* approval.

The temperature control of the gas-fired unit is of the on-and-off type, actuated by a *thermostat* located on the panel board. When the temperature of the surrounding air falls below the setting, the thermostat operates a contactor which starts the motor driving the fans. There is then a purging period of 30 sec during which time the exhauster fan removes any accumulation of gas from the combus-

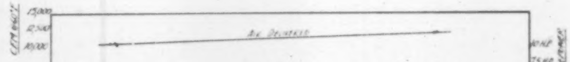


Fig. 8—Characteristic curves 1941 unit heater showing results of tests

Table 1—Heat Balance Data for 1,000,000 Btu Output Test

MEASURED VALUES

1	Heating value of gas, Btu per cubic foot at 30 in. Hg and 60 F	1128
2	Specific gravity	0.658
3	Fuel consumption as metered in cubic feet per hour	1142
4	Temperature of gas at meter	91 F
5	Pressure of gas at meter "inch water"	0.925
6	Barometer reading "inch Hg"	29.15
7	Exhaust gas analysis	Per Cent
	(a) CO_2	10.8
	(b) O_2	2.1
	(c) CO	0.0
8	Temperature of gases at exhauster	450 F
9	Temperature of air at inlet to fans	89.7 F
10	Temperature of air at discharge ducts approximately 11 feet beyond heater outlet	172.5 F
11	Voltage at fan motor	234
12	Amperes at fan motor	14.4
13	Power factor	0.75
14	Motor Efficiency (from manufacturers' data)	85%
15	Fan speed, revolutions per minute	928
16	Average reading at Pitot tube in outlet ducts (inches of water)	0.2695

CALCULATED VALUES

1	Volume of gas burned, corrected for meter calibration, cubic feet per hour referred to 60 F and 30 in. Hg	1052
2	Heat input in fuel, Btu per hour	1,186,000
3	Pounds dry gas, per pound of fuel at exhauster	17.15
4	Horsepower used by fans	4.98
5	Air delivered, as measured by Pitot tube, cubic feet per minute referred to 60 F and 30 in. Hg	10,625
6	Air delivered, according to characteristic curve of fan manufacturer, cubic feet per hour referred to 60 F and 30 in. Hg	10,890
7	Temperature rise of air through heater	82.8 F
8	Heat imparted to the air, Btu per hour.	
	(a) Based on Pitot tube air volume	968,000
	(b) Based on volume air from fan curve	993,000

HEAT BALANCE

	ITEM	BTU PER HOUR	PER CENT HEAT
1	Heat input in fuel	1,186,000	100
2	Heat loss due to water from combustion of hydrogen (latent plus sensible heat)	131,200	11.08
3	Heat loss due to dry chimney gases	78,700	6.64
4	Heat loss due to unburned combustible	0.0	0.0
5	Useful heat from fuel Items No. 1 minus 2 + 3 + 4	976,100	82.28
6	Heat imparted to the air based on volume as read by Pitot tube and air temperature rise	968,000	81.6

Table 2—Heat Balance Data for 1,250,000 Btu Output Test

MEASURED VALUES

1	Heating value of gas, Btu per cubic foot at 30 in. Hg and 60 F	1128
2	Specific gravity	0.658
3	Fuel consumption as metered in cubic feet per hour	1485
4	Temperature of gas at meter	90.75 F
5	Pressure of gas at meter (inch water)	3.2
6	Barometer reading (inch Hg)	29.06
7	Exhaust gas analysis	Per Cent
	(a) CO_2	11.2
	(b) O_2	1.8
	(c) CO	0.0
8	Temperature of gases at exhauster	533.5 F
9	Temperature of air at inlet to fans	87.1 F
10	Temperature of air at discharge ducts approximately 11 ft beyond heater outlet	181.3 F
11	Voltage at fan motor	225
12	Amperes at fan motor	17.9
13	Power factor	0.836
14	Motor efficiency (from manufacturers' data)	85 per cent
15	Fan speed, revolutions per minute	1033
16	Average reading at Pitot tube in outlet ducts (inches of water)	0.3474

CALCULATED VALUES

1	Volume of gas burned, corrected for meter calibration, cubic feet per hour referred to 60 F and 30 in. Hg	1350
2	Heat input in fuel, Btu per hour	1,523,000
3	Pounds dry gas, per pound of fuel at exhauster	16.55
4	Horsepower used by fans	6.64
5	Air delivered, as measured by Pitot tube, cubic feet per minute referred to 60 F and 30 in. Hg	11,900
6	Air delivered, according to characteristic curve of fan manufacturer, cubic feet per hour referred to 60 F and 30 in. Hg	11.780
7	Temperature rise of air through heater	94.2 F
8	Heat imparted to the air, Btu per hour	
	(a) Based on Pitot tube air volume	1,232,000
	(b) Based on volume air from fan curve	1,218,000

HEAT BALANCE

	ITEM	BTU PER HOUR	PER CENT HEAT
1	Heat input in fuel	1,523,000	100
2	Heat loss due to water from combustion of hydrogen (latent plus sensible heat)	174,200	11.43
3	Heat loss due to dry chimney gases	120,500	7.91
4	Heat loss due to unburned combustible	0.0	0.0
5	Useful heat from fuel Items No. 1 minus 2 + 3 + 4	1,228,300	80.66
6	Heat imparted to the air based on volume as read by Pitot tube and air temperature rise	1,232,000	80.8

tion chamber. At the end of this time the *pilot valve* opens and the electric spark ignition comes on simultaneously to light the pilot gas. The gas pilot flame warms a thermocouple (of pilotstat) which makes the electrical contact to open the main gas valve. Approximately one minute is required, after the pilot lights, to bring the thermocouple up to temperature and cause the pilotstat to open the main gas valve. One minute later the electric spark ignition is cut off and the heater is then in normal operation.

If for any reason the pilot does not light, the entire heater is shut off 45 sec after the pilot valve opens. The safety device requires manual re-setting before the cycle can be repeated. If the pilot fails and goes out at any time during the operation, the pilotstat breaks the circuit and the main gas valve closes in about 30 sec.

If the gas pressure should drop to less than about one-half the normal value, a *vaporstat* in the gas line between the gas regulator and the burner cuts out the main gas valve. This instrument also requires manual re-setting before the cycle can be repeated.

A *sail-switch* is located in the air stream. If for any reason, such as burned-out motors or broken belts, the fans are not creating sufficient air velocity to throw this switch, the main gas valve cannot open.

Near the air discharge louvers is placed a *temperature limit switch.* When the discharge air temperature reaches a pre-determined maximum, this switch causes the main gas valve to close. A *pressure switch* (sensitive vaporstat) in the stack also cuts out the main gas valve in the event the stack should become clogged; an increase of pressure in the stack equal to ½ in. water column is sufficient to actuate this switch.

After the room is up to temperature, the thermostat cuts off the gas to the burner. A *furnacestat* is provided to permit the fans to operate until the unit is cooled, after which time the fans are automatically turned off. When the thermostat again calls for heat, this cycle is repeated.

The Engineering of the Application of Unit Heaters to Buildings

In order to decide upon the most suitable application of unit heaters to a given building, it is necessary to determine, *first,* the heat loss from the building; *second,* the number of units to be used; *third,* the location of the units with regard to the plan of the building and with regard to height.

The heat loss from the building is of course determined by the standard methods as stated in THE ASHVE GUIDE. However, it will not do to assume that the temperature at the walls and especially that under the roof are the same as the desired temperature either at the floor level or at the operators' working or breathing level. Experience seemed to indicate that for a given temperature at the working level, approximately 6 ft from the floor, the temperature under the roof for example was likely to be considerably lower when unit heaters, especially the floor mounted type, were used than when suspended heaters or those without forced air circulation are used. For direct radiation heating, the heat losses can be predetermined quite accurately by the use of factors published in The ASHVE Guide and similar manuals, but no publication known to the authors included the data desired, applying when floor mounted, forced circulation, direct fired heaters are used.

Accordingly, it was decided to make temperature measurements in an actual industrial building of large size. This machine shop building is 400 ft long by 94 ft wide by 55 ft high from the floor to the peak of the roof as shown in Fig. 9; 100-ft length of the building at the south end has a floor level approximately 15 ft higher than the remaining portion of the building, and a space about 80 ft long by 20 ft wide at the southwest corner is enclosed and could not be entered during the tests. One gas-fired heater is located in the middle of each end of the building, and two heaters are located at approximately even spacing along the 400-ft east wall. Each of these floor-mounted heaters delivers 12,000 cfm or a total of 2,880,000 cu ft per hour; the volume of the building is approximately 1,343,000 cu ft, and in terms of building volume, the air is turned over a little more than two times hourly. This factor is largely responsible for reducing the temperature differentials between floor and ceiling. The heaters drawing air from the floor line deliver it to the room at a velocity of about 2000 fpm, with an effective air carry across the entire width of the building. The distance carry is determined by the laws governing the dissipation of velocity of jets, which laws however are not very generally known. Among the factors affecting the carry are the size of the air stream, its initial velocity, its direction (whether having an upward or a downward component), its temperature differential above the surrounding air, and the presence of obstructions, which may either block the stream or create eddy currents which cut down the effective throw. A low roof on the other hand may increase the throw over that in a high building. In our test, the two middle nozzles on the heaters were generally pointed toward the middle of the building or at right angle to the side walls, with the two end nozzles at a slight angle (approximately 30 deg) away from the direction of discharge from the central nozzles.

For making the test, some means had to be provided for locating temperature sensitive elements at the various levels in the building. Of the various ideas suggested, such as telescopic means, towers, pulleys and strings, and balloons, after eliminating those that were costly or that did not permit of immediate testing, the balloon method was decided upon. Light thread was fastened to hydrogen filled balloons, and thermometers were fastened to the string at a point just below the balloons, and at 10 ft intervals to the floor and at the breathing level about 5 ft from the floor.

Five stations were located across the width of the building, approximately 20 ft apart as shown in Fig. 9, with balloons and string of thermometers at each. Eleven stations were located along the length of the building, the first 3 being at the middle of the 20-ft bays beginning at the north wall, and the remaining 8 being at two-bay or 40-ft intervals.

The procedure was to record the temperature at one station, then

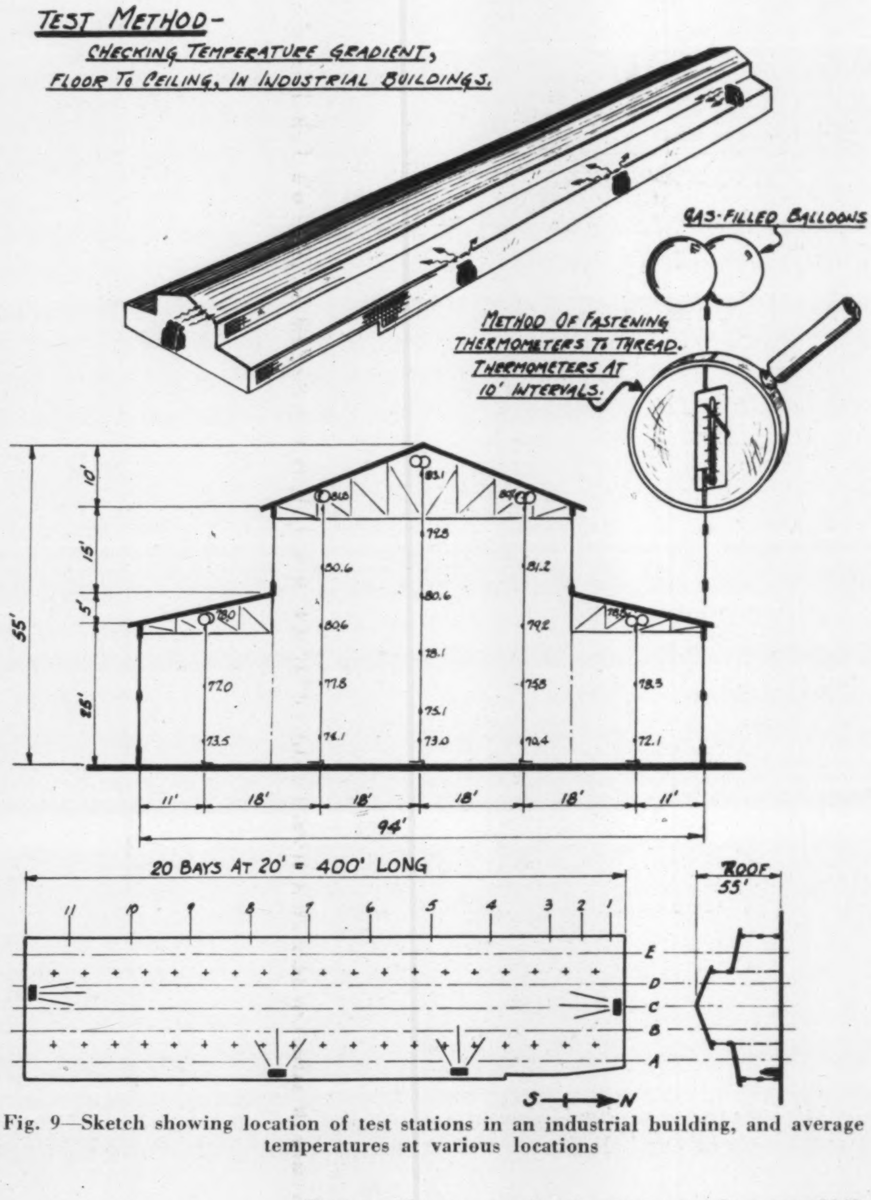


Fig. 9—Sketch showing location of test stations in an industrial building, and average temperatures at various locations

Table 3—Readings of Temperature in an Industrial Building
(Refer to Fig. 9 for location of measuring stations)

Cross Section	Station A	Station B	Station C	Station D	Station E	Location of Thermometers Below Roof	Cross Section	Station A	Station B	Station C	Station D	Station E	Location of Thermometers Below Roof
1	79	80	80	78	78	1st below roof	6	80	81	84	80	79	1st below roof
	....	80	80	78	....	2nd below roof		....	82	80	81	78	2nd below roof
	....	80	80	76	....	3rd below roof		....	80	82	78	....	3rd below roof
	....	79	77	80	....	4th below roof		....	78	80	78	....	4th below roof
	....	....	76	....	....	5th below roof		....	....	74	....	....	5th below roof
	69	70	72	72	65	Breathing level		78	72	72	70	74	Breathing level
3	74	82	82	80	79	1st below roof	7	80	82	83	80	78	1st below roof
	....	82	78	78	....	2nd below roof		....	80	80	80	78	2nd below roof
	....	79	82	87	....	3rd below roof		....	80	81	79	....	3rd below roof
	....	74	79	82	....	4th below roof		....	78	79	73	....	4th below roof
	....	....	74	....	....	5th below roof		....	....	75	....	....	5th below roof
	68	64	68	66	70	Breathing level		79	72	70	70	73	Breathing level
5	81	82	82	80	76	1st below roof	9	....	80	85	84	82	1st below roof
	....	80	78	80	76	2nd below roof		72	80	82	....	80	2nd below roof
	....	80	80	80	....	3rd below roof		....	75	80	80	....	3rd below roof
	....	78	78	78	....	4th below roof		....	....	78	75	....	4th below roof
	....	....	76	....	....	5th below roof		....	....	74	....	....	5th below roof
	81	79	74	70	70	Breathing level		74	74	72	70	74	Breathing level

Note: All temperatures are in degrees Fahrenheit. Outside temperature at time of test was 36 F. First thermometer was approximately 2 ft below roof; second was 10 ft below first; third was 10 ft below second, etc., at 10 ft intervals. Breathing level was 5 ft above floor.

move to the next and do the same, until all stations in one cross-section of the building had been covered; then move to the next cross-section along the length, read and record all temperatures at successive stations in this cross-section; and repeat until all cross-sections along the length had been covered. At each station, after allowing time for the thermometers to reach temperature equilibrium, one man pulled the balloons down and read the thermometers in rapid succession while another man recorded the temperatures. To make sure that the thermometer readings did not change while being pulled down, in the short time between leaving their positions and being read, a test of the time lag of the thermometers had previously been made. All of the thermometers on one suspended thread could be read in approximately 15 sec, and the time lag of the thermometers was so much greater than this that the change in the reading while lowering was negligible.

The hydrogen-filled balloons supporting the threads were about 15 in. in diameter when inflated. With six thermometers attached, two balloons were required per thread or per station, as one balloon was not sufficient to support them; however, with two balloons attached, if one burst from hitting some sharp projection just below the roof, the other furnished sufficient buoyancy and resistance to falling, to give plenty of time to get to this particular station and catch the thermometers before they reached the floor.

The temperature marked at each location in Fig. 9 is the average of the readings at the various points along the length of the building. In Table 3 are given the tabulated measurements, from which the variations along the length of the building, and the influence on such variations of proximity to or distance from the heaters, can be judged. The outside temperature at the time of these tests was about 36 F. It will be noted that from the breathing level up to a point just below the peak of the roof the increase of temperature averaged 10.1 F. This gives a basis upon which the heat losses from a building heated by floor mounted unit heaters can be calculated.

The number of heaters required is then calculated from the capacity of a unit, which ranges from 750,000 to 1,500,000 Btu per hour. As to location, floor mounting is preferred wherever it is feasible; and while the heaters can either be located along the walls discharging inward toward the middle of a wide building, or near the middle discharging outward toward the walls, the former is preferred. Although no exact comparative tests have been made, it is judged that placing the heaters in the middle discharging toward the walls increases the temperature along the walls, where it will do no good, but will increase the heat loss; and also that it results in slightly less uniform temperature distribution. If floor space is not available, the heaters can be suspended from side walls or from columns or roof trusses; in this case it is recommended that a return air duct be run within a few feet of the floor so that the colder air is taken from this level.

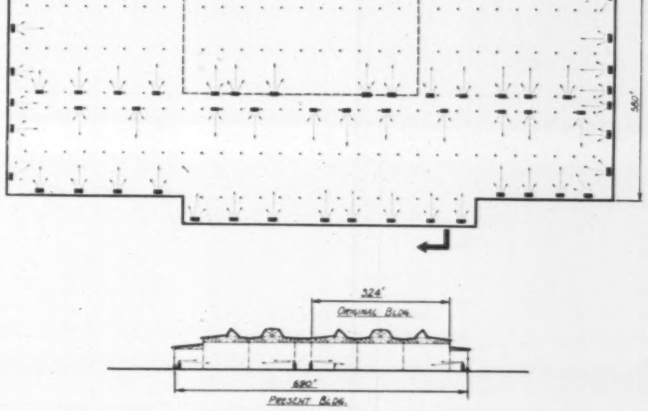


Fig. 10—Plan of ordnance plant, showing location of heaters

Locating the heaters near the walls simplifies venting. Since the unit includes an exhauster, no stack is required, and often the flue need merely be run through the wall, extended a few feet vertically and weather-capped.

The Relation of Direct-Fired Heaters to the Defense Program

The large direct-fired unit heater in the present industrial situation assumes added importance because: *First,* heat for large projects can be furnished quickly. *Second,* a direct fired heating system can readily be expanded, as building extensions become necessary, simply by increasing the number of units, without requiring expansion of a central plant. *Third,* not only is less labor and material required than in other heating systems, but the engineering required is less complicated, which is a great advantage at present when engineers are scarce.

To illustrate these points and their relationship to national defense a typical example is cited:

A large machine shop, built for

the U. S. Naval Ordnance, was heated by twenty-two 1,000,000 Btu gas-fired units (Fig. 10). The shop was enlarged to an area about six times the original plan with a total hourly heat loss of about 80,000,000 Btu. The heating plant was easily expanded to meet the new condition by simply adding 58 more units.

Thus the advent of the direct-fired unit heater adapted to either gas or oil firing is particularly timely with reference to the national defense program.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

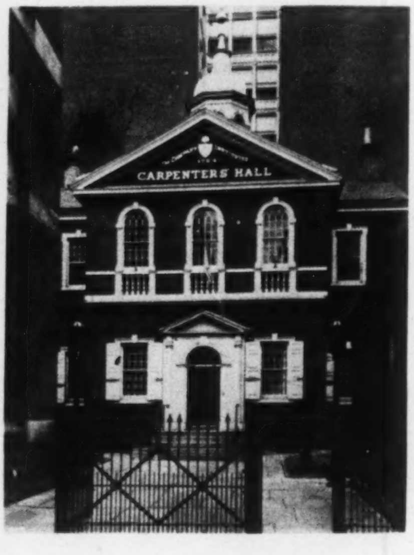
Adopted at Council Meeting, January 29, 1926.

Philadelphia Meeting Opens

Members of the Society in Philadelphia are ready for an influx of visitors for the Society's 48th Annual Meeting to be held the week of January 26 at the Bellevue-Stratford Hotel. Visitors are expected from all parts of the United States and Canada for this four-day meeting. The Council of the Society will get an early start and many of the technical committees will hold sessions in advance of the general meeting.

M. F. Blankin, general chairman of arrangements, announces that the program will include a series of technical sessions on subjects developed through Society research and at cooperating institutions, many of which have definitely contributed to the emergency program now under way. A special business session for members only will be opened by Pres. W. L. Fleisher at the Bellevue-Stratford Hotel at 9:30 a.m., January 26 and there will be 5 technical sessions, and a joint session with the *National Warm Air Heating and Air Conditioning Association.*

Representatives of the Society's 31 Chapters will be in attendance and a Chapter Delegates Conference will be held on Monday evening with E. K. Campbell presiding.



Carpenters Hall

Special entertainment events will be climaxed by the annual banquet on Wednesday evening in the grand ballroom of the Bellevue-Stratford.

The fourth award of the F. Paul Anderson Medal will be made to Dr. F. E. Giesecke, Professor Emeritus at A. and M. College of Texas and past president of the ASHVE. The medal will be presented by Thornton Lewis, past president of the Society. The presentation of the Past President's emblem to W. L. Fleisher will be made by W. H. Driscoll, also past president of the Society.

Liberty Bell

Provision has been made for special features for the ladies, and visiting members will also find a series of interesting inspection trips planned for them.

The week of January 26 will be heating, ventilating and air conditioning week in Philadelphia as the 28th Annual Convention of the *National Warm Air Heating and Air Conditioning Association* will convene at the Benjamin Franklin Hotel.

The detailed programs of the events for the week and the list of exhibitors at the 7th International

January 26th

Independence Hall

Heating and Ventilating Exposition at the Commercial Museum will be found on pp. 41-54.

DRISCOLL ADDRESSES MASSACHUSETTS MEETING

November 18, 1941. Pres. J. W. Brinton called the regular meeting of the Massachusetts Chapter to order at the Massachusetts Institute of Technology, Cambridge, with 45 members and guests present.

He called attention to a letter received from the Office of Production Management in Washington, D. C., asking for applications from engineers who could help in their program.

D. J. Edwards, after discussing the social evening planned for December, announced that Stuart Rogers would be the speaker at the January meeting.

W. T. Jones, past president of the Society, introduced W. H. Driscoll, Syracuse, N. Y., another past president of the ASHVE, who gave an excellent talk covering some of the history of the Society. He then spoke on the practices in heating and ventilating during which the square foot was amputated. His talk created considerable discussion, and a rising vote of thanks was extended to Mr. Driscoll. The meeting adjourned at 10:00 p. m.

Wm. Penn House

OKLAHOMA REPORTS ON MEETINGS

J. H. Carnahan, secretary of the Oklahoma Chapter of the Society, reports great satisfaction with the interest in chapter meetings this season, reporting an average attendance of 30 at each meeting.

At the meeting held October 20, Dr. F. E. Giesecke gave an interesting resumé of the research activities and data on hot water flow and piping, which developed into a discussion on panel heating.

At the November 17 meeting, W. O. Bynum, Dallas, Tex., presented a talk on the subject of the application of refrigeration equipment to blast furnaces to increase their output and improve the quality of the product. He also gave a rather complete discussion of a conduit air conditioning system in its application in a new 33-story office building now under construction in Dallas.

Mr. Carnahan announced that tentative arrangements were made for talks on mechanical equipment and a tour of inspection of the Will Rogers Bombardment Base for the December meeting, and for the January meeting, members of the Oklahoma Natural Gas Co. will present the subject of gas combustion, burner and draft adjustments, boiler, furnace and other heating apparatus installations and service suggestions and related data. He also announced that it was planned to have a man from the *American Gas Association* give a talk on the tests required for the approval by *AGA* and why these tests are necessary.

JOHN JAMES ON RESEARCH AT KANSAS CITY

October 3, 1941. The first regular meeting of the season held by the Kansas City Chapter was at the Hotel President, with Pres. Gustav Nottberg presiding and 21 members in attendance.

Due to the death of E. M. Jolley and the departure of Roger Campbell from the city, a change of officers was necessitated and the following are serving the chapter:

President—Gustav Nottberg.
Vice-President—M. M. Rivard
Treasurer—L. E. Boyd.
Secretary—F. J. Dean, Jr.
Board of Governors—W. L. Cassell, D. M. Allen and Kenneth Stevens.

Following a report by the treasurer, an associate Society of the chapter was suggested by F. A. Kitchen and seconded by L. A. Stephenson, to be termed the *Bottleneck Society*. It was unanimously agreed that President Nottberg should act as its president and through his wide experience and skill, he would guide the chapter through any bottleneck problems.

President Nottberg, after a short business discussion, introduced John James, New York, N. Y., technical secretary of the ASHVE, who spoke on the research trends in heating, ventilating and air conditioning. He discussed the research trends toward the establishment of a more uniform comfort and health standard for various types of environments, and explained a laboratory technique for measuring the adjustments made by the human body when a person passes suddenly between two environments with widely different heat properties.

Mr. James further spoke on the evaluation of fundamental engineering data obtained from carefully planned research programs for more accurately determining proper heating and cooling loads. He also presented new data covering the thermodynamic properties of moist air and the heat flow through walls, roofs, basement floors, glass blocks and various types of window appurtenances.

Mr. James presented his material with slides and the subject was of great interest to the chapter. According to Secretary Dean's report, this was one of the finest meetings ever held by the chapter.

THE ENGINEER'S IMPORTANCE DISCUSSED AT ONTARIO

December 1, 1941. With 55 members and guests in attendance, Pres. C. Tasker called the regular meeting of the Ontario Chapter to order at the Royal York Hotel, Toronto.

Following dinner President Tasker announced the 48th Annual Meeting of the Society to be held in Philadelphia, Pa., January 26-29, 1942.

He then called upon V. J. Jenkinson, who introduced M. C. Lazier, the guest of the evening. Mr. Lazier spoke on *The Engineer,* giving an inspirational address on the place of the engineer in the world of today, and what is more important, the world of tomorrow.

E. R. Gauley extended to Mr. Lazier, on behalf of the Chapter, their deep appreciation for the splendid address.

Mr. Jenkinson called attention to the January chapter meeting, stating that the program would be especially designed for the heating industry. He announced that Gordon Hill will speak on warm air heating as applied to the war effort, and J. P. Fitzsimons will speak on steam heating as applied to the war effort. Mr. Gauley will also address the January meeting on the benefits derived from the Society. Mr. Jenkinson urged each member to bring a guest to this meeting.

WASHINGTON, D. C., HEARS SUBJECT FOR DEFENSE INDUSTRIES

November 12, 1941. The regular meeting of the Washington, D. C., Chapter was attended by 45 members and guests, and was held at the Dodge Hotel. Following dinner the business meeting was held in the Garden House, with Pres. F. A. Leser presiding.

The minutes of the October meeting were approved as read, and the Secretary made an appeal for engineering talent, needed for the Office of Production Management.

K. F. Baldwin submitted the treasurer's report, which was followed by a report on the activity of the membership committee by J. H. Fogg, chairman. I. M. Day, chairman of the entertainment committee, described a proposed ladies' night, and after some discussion it was agreed to hold such an affair.

The speaker of the evening, J. R. Vernon, was then introduced. He gave an interesting talk on automatic temperature and humidity control for the Defense Industries. After a short period of questions and discussion the meeting adjourned at 10:00 p. m., according to F. M. Thuney, secretary of the chapter.

NEW YORK CHAPTER AWARDS DEFENSE STAMPS

The annual Christmas party held by the New York Chapter of the Society on the evening of December 15, at the Building Trades Club, New York, was turned into a defense party which was greatly enjoyed by 150 members, their wives and friends. Pres. Joe Wheeler, Jr. called on W. L. Fleisher, president of the Society, who welcomed the members, and during the excellent dinner there was much hilarity resulting from the actions of an "annoying" waiter.

Those present were entertained by a magician, an exhibition of roller skating, a memory expert and a quiz program. A program of motion pictures was given, which included films on U. S. Defense, the training of West Point cadets, a scenic film of Sun Valley, and a sports film. Throughout the evening dancing was enjoyed by many.

Instead of awarding prizes the entertainment committee, headed by R. C. Bonthron, had arranged to award the winner of the various games a book of Defense Stamps in units of $1.00, $2.00, $3.00 and $5.00. This made a good start on a book of $18.75 in Defense Savings Stamps and the recipients were urged to complete the book.

This plan when presented to the Postmaster of New York City by the Officers of the New York Chapter, was received with enthusiasm and many organizations will be invited to adopt the plan which was proposed by Messrs. Bonthron, Bond and Wheeler.

The accompanying picture shows the New York Chapter Officers purchasing Defense Stamps for the Christmas party from Albert Goldman, postmaster of New York City.

November 17, 1941. The monthly meeting was called to order by Pres. Joe Wheeler, Jr., following dinner at the Building Trades Club.

A letter from A. J. Offner, member of the Society's Council, was read, calling attention to the 1944 Annual Meeting of the Society as being the 50th anniversary of the Society. He pointed out that since the first meeting of the Society was held in New York, and in view of the fact that the 1944 meeting is scheduled to include an Exposition as well, a motion was offered by H. H. Bond, seconded by E. J. Ritchie, to extend an invitation to the Society to hold its 1944 meeting in New York. The motion was unanimously carried.

C. S. Pabst, chairman of the nominating committee, offered Mr. Wheeler as delegate and Mr. Bond as alternate to serve on the Nominating Committee of the Society to represent the New York Chapter at the Philadelphia Annual Meeting

KEEP THEM FLYING BY BUYING
UNITED STATES
DEFENSE SAVINGS BONDS—STAMPS

Buying Defense Stamps for New York Chapter Christmas Party. Left to Right: Joe Wheeler, Jr., *President,* New York Chapter ASHVE; Albert Goldman, Postmaster, City of New York; R. C. Bonthron, *Chairman,* Entertainment Committee, A. V. Hutchinson *Secretary* ASHVE; Harry H. Bond, *Vice-President,* New York Chapter

of the Society in January 1942. The motion of O. O. Oaks that the nominations be closed and accepted as reported was seconded by Mr. Olson and carried by a vote of the membership.

The report of the nominating committee by Mr. Ryan was enthusiastically received, and the names of 20 new members were read and referred to the Board of Governors to be passed on and referred to the membership at the next chapter meeting.

The secretary then read a letter from C. E. Holmes Placement Officer of the Office of Production Management in Washington, who requested the Chapter's cooperation in recruiting personnel for the Defense effort.

At the conclusion of the business session, President Wheeler introduced the speaker, J. M. Dalla Valle, New York State Department of Industrial Hygiene, who spoke on ventilation and exhaust in industry. Mr. Dalla Valle's address was exceptionally well received. His manner of presentation on this subject brought out a great deal of interesting comment.

WEATHER BUREAU EXPERT ADDRESSES WESTERN MICHIGAN

November 10, 1941. The November meeting of the Western Michigan Chapter was held at the Burdick Hotel, Kalamazoo, Mich., with 30 members and guests attending. The meeting was called to order by Pres. W. G. Schlichting, and the October minutes were read and approved.

The president then turned the meeting over to F. C. Warren, vice-president, who introduced Paul Johnson, head of the U. S. Weather Bureau in Grand Rapids, who gave a very interesting talk on new ideas in meteorology. He answered numerous questions and considerable discussion followed.

T. D. Stafford then reported on the plans for the next chapter meeting, which he stated were well under way. He announced that Dr. M. B. Ferderber, Fellow of Department of Hygiene, University of Pittsburgh Medical School, would be the guest speaker and would talk on research for air conditioning in treatment of disease.

On motion of Vice-President Warren and seconded by Mr. McConner the meeting was then adjourned.

GEORGIA TECH RESEARCH DISCUSSED AT ATLANTA

November 4, 1941. The regular monthly meeting of the Atlanta Chapter was held at the Atlanta Biltmore Hotel, and was attended by 29 members and guests with Pres. S. W. Boyd presiding.

Following the reading of the minutes of the previous meeting, which were approved as read, F. L. Laseter, chairman of the codes committee, reported that the Atlanta heating code was now complete and available for distribution.

C. L. Templin, chairman of the nominating committee, offered the following nominees as officers for 1942: *President*—L. F. Kent; *Vice-President*—A. H. Koch; *Secretary* F. L. Laseter; *Treasurer*—M. M. Crout. President Boyd then announced that these nominees, as well as any others that might be placed before the Chapter, would be voted upon at the next meeting of the Chapter.

President Boyd then announced that the delegate to the Annual Meeting in Philadelphia would be selected by the incoming officers next month. He also pointed out that from a notice from the headquarters office it was noted that the initiation and dues for chapter mem-

New York Chapter Officers 1941-1942

W. M. Heebner
Treasurer

Joseph Wheeler, Jr.
President

H. H. Bond
Vice-President

J. A. Heller
Board of Governors

C. R. Hiers
Secretary

C. S. Pabst
Board of Governors

C. S. Koehler
Board of Governors

D. F. Parker
Board of Governors

R. A. Wasson
Board of Governors

bership are not subject to the new Revenue Act on Society dues.

A letter from the Office of Production Management in Washington, D. C., regarding the need for technically trained men to act as staff experts in various fields of production activities under the OPM, was then read, and anyone interested was requested to contact the secretary for further information.

As a special feature of the meeting, President Boyd introduced H. King McCain, a member of the Society's Committee on Research, who gave the chapter a preview of the technical paper covering the recent attic fan test conducted by Georgia Tech. The paper was prepared by W. A. Hinton and A. F. Poor. Mr. McCain introduced Dr. Weber of Georgia Tech and Mr. Poor, a former student, both of whom did considerable work on this test. A motion was made by Mr. Kent that the chapter go on record as having full confidence in the chapter's research committee to enable them to study and comment on this technical paper. The motion was seconded and carried unanimously.

W. M. Garrard, a member of the Atlanta Chapter, was introduced as the main speaker of the evening, and spoke on the subject of air distribution. He gave a very interesting and thorough presentation on the general subject of air distribution, covering the problems involved as well as methods available for meeting these problems. He also commented on the various types of grilles available, the characteristics of each and their most widely used applications. He brought out the point that by the proper application of grilles, noticeable drafts could be avoided, more even temperature distribution obtained, and objectionable noises eliminated.

Considerable discussion followed, and according to Secretary Koch's report, the entire meeting was conducted by members of the local chapter and considerable interest in the subject was aroused by the program. There being no further business the meeting was adjourned at 10:45 p. m.

SOUTHERN CALIFORNIA MEMBERS MEET

November 5, 1941. The regular meeting of the Southern California Chapter of the Society was held at Eatons Chicken House, Los Angeles, with 55 members and guests in attendance.

After dinner the meeting was called to order by Pres. A. J. Hess, and the minutes of the previous meeting were read and approved. It was reported that 30 listings had been obtained for the directory and at least that many more were expected during the next month. President Hess stated that a student section of the local chapter was to be formed for the purpose of assisting young engineers in heating, ventilating and air conditioning, and promoting a closer relationship between the engineering profession and the Society.

At the conclusion of the business session W. C. McHenery spoke on the subject of the application and installation of the sterilamp in air ducts, and a general coverage of the treatment of air and reduction of organisms, which he illustrated with sound film. As reported by Leo Hungerford, secretary of the Chapter, this proved such an interesting subject that the meeting continued an hour longer than usual, with many questions asked during the discussion.

HENRY GOMBERS, LIFE MEMBER, DIES AT 81

A Life Member of the Society, Henry B. Gombers, secretary emeritus of the *Heating, Piping and Air Conditioning Contractors National Association,* died at the age of 81 on December 22, at Orange, N. J. For more than 30 years he had actively served the industry, and a host of friends attended funeral services at East Orange, N. J., on Wednesday, December 24.

Mr. Gombers was born in Brooklyn, N. Y., January 21, 1860, the son of Joseph Alexander and Susan Wickes Gombers, and attended the public schools of that borough.

His first business experience was in the office of the great printing press establishment of R. Hoe and Co., New York. In 1877, Mr. Gombers, having a desire to go into Wall Street, made an engagement with the banking house of Charles H. Welling and Son and soon became interested in the firm of W. B. Welling. He retained his interest in this firm until 1883, when he became one of the charter members of the National Petroleum Exchange, which, after consolidation with the New York Mining Exchange, was succeeded by the New York Consolidated Stock and Petroleum Exchange.

Henry B. Gombers

On January 29, 1885 he married Elizabeth Jaredine Southmayd and they took up their residence in East Orange, N. J., in 1886, where they lived throughout the rest of their lives, celebrating their fiftieth wedding anniversary there in 1935. Mrs. Gombers died January 24, 1936.

Mr. Gombers, in 1887, accepted the position of cashier and office manager for the banking firm of Fox, Leonard and Co., of which firm, Jesse R. Grant, son of the late General U. S. Grant, was a member. In 1890 he left the firm of Fox, Leonard and Co. to transact a stock brokerage business on his own account, in which business he remained until the *Heating, Piping and Air Conditioning Contractors National Association,* then known as the *National Association of Master Steam and Hot Water Fitters,* sought him as its secretary, April 8, 1897.

After 33 years of service Mr. Gombers retired from active duty in 1930 and was elected secretary emeritus by the Board of Directors of the *HPACCNA.* The New York City association of the *HPACCNA* also elected him secretary emeritus in the same year.

Retirement did not mean that he lost touch with the industry for he was a regular attendant at all the annual conventions and in June 1941, made the trip to San Francisco and return by air so that he could be present at the annual convention.

Upon his retirement he was elected an honorary member of the Eastern Trade Golf Association, the American Trade Association Executives, and the Trade Association Executives in New York City following long periods of active membership in these organizations. He was a charter member of the American Trade Association Executives and throughout his career, worked for the upbuilding of the trade association movement. His many friends have lost a good friend.

W. C. OKE DIES IN TORONTO

William Charles Oke, a member of the Society since 1934, died suddenly of a heart attack at his home in Toronto, Ont., on November 18, 1941.

Mr. Oke was born March 18, 1908 at London, Ont., and attended elementary and secondary schools in London, with four years at the London Technical School. In 1925 he was employed by the Carrier Engineering Corp., Newark, N. J., for a period of five years, working in the various Eastern States. During this time he spent considerable time on preliminary work on the air conditioning system in the Capitol in Washington, D. C.

In 1930 he returned to Canada where he became associated with Sheldons, Ltd., Galt, Ont. Later he went to their Toronto office where he worked until 1937. During this time he designed the installation of a large number of air conditioning systems in theaters across Canada. He was one of the most experienced engineers in this field in this district, and in 1937 he was employed by Weathermakers Canada Ltd., Toronto, which afforded him an opportunity to again associate himself with his many friends at the Carrier Corp. He remained with them until his death.

Mr. Oke had a large circle of friends in the air conditioning industry, and was particularly well liked among all those with whom he worked as he had the happy faculty of cultivating friendship. He was a member of the *Professional Engineers* and of the *Canadian Air Conditioning and Refrigerating Institute,* and was always an active member in the Toronto Chapter of the ASHVE.

Mr. Oke is survived by his widow, Grace Luck Oke and son William, Jr., to whom the Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere and heartfelt sympathy. His loss will be keenly felt by all with whom he associated.

DEATH OF E. B. GORDON, JR., LIFE MEMBER

Word has just been received of the death of Edward B. Gordon, Jr., Minneapolis, Minn. Mr. Gordon, a Life Member of the Society, was born February 15, 1874 at Lynn, Mass., where he received his early education. He was graduated from the Massachusetts Institute of Technology, Cambridge, in 1906 with a degree of S.B. in mechanical engineering.

He spent two years as draftsman with the Paul System Co., Boston, and in 1898 joined the staff of the A. B. Franklin Co., as draftsman and estimator. He then went with the National Steam Economizer Co., Springfield, Mass., and in 1900 was transferred to their Norwich, Conn. office, as foreman of erecting feed water heaters and fan work, and as superintendent of construction.

He was also connected with the Ross and Seabury Co., Boston as draftsman and estimator, and in 1903 became associated with the Consolidated Engineering Co., Chicago, where he remained for some years as superintendent of construction, engaged in vacuum heating, temperature regulation and power plant design.

He later joined the Charles L. Pillsbury Co., St. Paul, Minn. He became Vice-President of the Pillsbury Engineering Co., Minneapolis, in 1931, becoming President of the company in 1932, a position which he held until his death.

Mr. Gordon served as secretary of the Minnesota Chapter of the Society in 1926. The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere sympathy to his family.

HOMER R. LINN PASSES

The many friends of Homer R. Linn, a member of the Society for 26 years will learn of his recent death with regret. Mr. Linn was born on January 9, 1873 at Byron, Ill., where he received his early education. He attended the University of Illinois and received a degree in mechanical engineering in 1896.

For a number of years Mr. Linn was General Sales Manager for the Kawneer Mfg. Co., Niles, Mich. In 1917 he became industrial engineer for the American Radiator Co., Chicago, and in 1926 became engineer of the Western Executive Office of the company, where he remained until 1935. Since then he maintained a consulting engineering service under the name of Brooke and Linn, with offices in Chicago.

Mr. Linn was also a member of the *American Oil Burner Association* and a member of the Committee of Ten, Coal and Heating Industries. He served on the Board of Governors of the Illinois Chapter of the ASHVE in 1922-23, was vice-president in 1924 and became its president in 1925.

The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their deepest sympathy to his family who survive.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his

grade, the Council shall vote upon the election of the proposed **Candidate for membership by letter ballot.** During the past month 22 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 15, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Anderson, Carl G., Mech. Engr., Armour Research Foundation, Chicago, Ill.	J. J. Aeberly W. A. Kuechenberg	J. J. Haines L. L. Narowetz, Jr.
Beach, Ralph L., Branch Mgr., York Ice Machinery Corp., Atlanta, Ga.	S. W. Boyd J. R. Hertzler	M. M. Crout H. K. McCain
Behrer, William H. Jr., Htg. & Air Cond. Engr., Behrer Nason Co., Mineola, L. I., N. Y.	Arthur Ritter E. A. Bennett	H. R. Denny R. R. Ferguson
Clark, Allan M., Sales Engr., Canadian Blower & Forge Co., Ltd., Toronto, Ont., Canada.	V. J. Jenkinson H. H. Angus	M. S. Woollard H. R. Roth
Ginzburg, Nicola, Designer & Draftsman, The Pusey & Jones Corp., Wilmington, Del.	A. J. Offner F. B. Rowley	John James J. V. Foa *(Non-member)*
Johnson, Raymond L., Research Engr., Young Radiator Co., Racine, Wis.	M. F. May W. A. Minkler	F. M. Young F. H. E. Weil
Kimmell, Phillip M., Asst. Mech. Engr., Eastman Kodak Co., Kodak Park, Rochester, N. Y. *(Advancement)*	R. P. Cook L. W. Leonhard	Quentin Treadway W. T. Miller
Lawrence, Lewis F., Jr., Branch Mgr., Minneapolis-Honeywell Regulator Co., Atlanta, Ga. *(Advancement)*	A. H. Koch W. J. McKinney	C. E. Johnson C. L. Templin
Ludwig, Willis D., Contract Engr., York Ice Machinery Corp., Atlanta, Ga.	S. W. Boyd J. R. Hertzler	M. M. Crout H. K. McCain
McKay, Albert W., Secy.-Treas., Conditioned Air, Inc., Macon, Ga.	S. W. Boyd M. M. Crout	H. K. McCain C. L. Templin
McKernan, Gordon S., Secy.-Treas., Reg. H. Steen Ltd., Toronto, Ont., Canada.	J. P. Fitzsimons H. R. Roth	A. M. Dion R. W. Bayles
Melton, Howard E., Manager, Howard E. Melton, Inc., Oklahoma City, Okla.	A. R. Morin J. H. Carnahan	E. F. Dawson E. W. Gray
North, Samuel L., Partner, North Bros., Atlanta, Ga.	C. L. Templin A. H. Koch	L. L. Barnes L. F. Lawrence, Jr.
Otts, John G., Sales Engr., York Ice Machinery Corp., Atlanta, Ga.	S. W. Boyd J. R. Hertzler	M. M. Crout H. K. McCain
Pinter, Joseph L., Owner, Joseph L. Pinter & Co., Morristown, N. J.	Herbert Curtis O. L. Maddux	T. W. Reynolds D. F. Parker
Powlesland, John W., Sales Engr., Canadian Sirocco Co., Ltd., Toronto, Ont., Canada.	H. R. Roth J. P. Fitzsimons	S. A. Jennings C. W. Gordon
Selden, Karl W. Jr., Dist. Repr., Minneapolis-Honeywell Regulator Co., Charlotte, N. C.	A. H. Koch Arvin Page	H. H. Hill W. B. Hodge
Shire, A. C., Tech. Dir., U. S. Housing Authority, Washington, D. C.	T. H. Urdahl C.-E. A. Winslow	A. L. Jaros G. L. Eadie
Simms, Herman, Draftsman, York Ice Machinery Corp., Atlanta, Ga.	S. W. Boyd J. R. Hertzler	M. M. Crout H. K. McCain
Strain, Andrew J., Sales Mgr., The Consumers' Gas Co. of Toronto, Toronto, Ont., Canada.	V. J. Jenkinson R. P. Allsop	D. O. Price R. W. Bayles
Williams, Donald D., Htg. Engr., Iowa-Nebraska Light & Power Co., Lincoln, Nebr. *(Advancement)*	H. W. Stanton Frederick Organ	C. E. Wiser K. T. Davis
Wilson, James, Service Engr., Darling Bros. Ltd., Montreal, Que., Canada.	W. J. Armstrong C. W. Johnson	R. R. Noyes A. M. Peart

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

Davis, Telford R., Mech. Engr., Indianapolis Power & Light Co., Indianapolis, Ind.

Eaton, William G. M., Engr., Pease Foundry Co. Ltd., Toronto, Ont., Canada. *(Advancement)*

Hyde, Dayton F., Vice-Pres., D. F. Edwards Heating Co., St. Louis, Mo.

Lavorgna, Michael L., Sales Engr., L. J. Mueller Furnace Co., Milwaukee, Wis. *(Advancement)*

Marshall, Orville D., Mfrs. Agent, Grand Rapids, Mich. *(Advancement)*

Peterson, Walter E., Design Engr., Sanderson & Porter, Chicago, Ill.

Sheffield, Raymond A., Owner, Air Conditioning Engineering Co., Cambridge, Mass. *(Reinstatement)*

Stephenson, Kiser A., Secy.-Treas., Stephenson Co., Atlanta, Ga. *(Advancement)*

Waterfall, Wallace, Director of Research Engrg., The Celotex Corp., Chicago, Ill.

Wells, Donald E., Sales Repr., Globe Machinery & Supply Co., Des Moines, Ia.

ASSOCIATES

Gates, Albert S. Jr., Assoc. Engr. (Naval Architect) Bureau of Ships, Washington, D. C.

Gribbon, J. Harry, General Mgr., Northwest Stove & Furnace Works, Inc., Portland, Ore.

Joyce, James J., Branch Mgr., The Powers Regulator Co., New Orleans, La.

Nelson, Axel A., Chief Engr., Federal Reserve Bank Bldg., North Kansas City, Mo.

Nicholson, Sterling J., Owner, Nicholson Inc., Durham, N. C.

Risley, George H., Branch Mgr., Cole Sullivan Engineering Co., Portland, Ore.

Roach, Edwin R., Htg. & Vtg. Engr., Baskervill & Son, Richmond, Va.

Strother, William E., Construction Engr., Barge-Thompson Co., Atlanta, Ga.

Smith, George E., Supervising Engr., Pinner, Middlesex, England.

JUNIORS

Houck, Robert C., Engr., Kimble Glass Co., Vineland, N. J.

Rosas, Milton L., Sales Engr., 514 Wesley Temple Bldg., Minneapolis, Minn.

Satlow, Abraham, Jr., Naval Architect, Philadelphia Navy Yard, Philadelphia, Pa.

Woolston, Robert H., Engr., Woolston Woods Co., Philadelphia, Pa.

Officers, Council and Committees

American Society of Heating and Ventilating Engineers
51 Madison Ave., New York, N. Y.

Officers

President	W. L. Fleisher
First Vice-President	E. O. Eastwood
Second Vice-President	J. H. Walker
Treasurer	M. F. Blankin
Secretary	A. V. Hutchinson
Technical Secretary	John James

Council

W. L. Fleisher, *Chairman* E. O. Eastwood, *Vice-Chairman*

A. E. Stacey, Jr., *Ex-Officio*

Three Years: A. P. Kratz, W. A. Russell, L. P. Saunders, C. Tasker.

Two Years: J. F. Collins, Jr., E. N. McDonnell, T. H. Urdahl, C.-E. A. Winslow.

One Year: E. K. Campbell, S. H. Downs, F. E. Giesecke, A. J. Offner, G. L. Tuve.

Advisory Council

F. E. Giesecke, *Chairman;* Homer Addams, R. P. Bolton, D. S. Boyden, W. H. Carrier, S. E. Dibble, W. H. Driscoll, H. P. Gant, E. Holt Gurney, John F. Hale, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, John Howatt, W. T. Jones, D. D. Kimball, G. L. Larson, S. R. Lewis, Thornton Lewis, J. I. Lyle, J. F. McIntire, F. B. Rowley and A. C. Willard.

Council Committees 1941

Executive—F. E. Giesecke, *Chairman;* E. O. Eastwood, A. J. Offner.
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